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BULLETIN OF THE RESEARCH COUNCIL OF ISRAEL

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p. 273, col. 1, l. 6 from bot.: *for* $\triangle^4$ *read* $\triangle^2$
, col. 2, l. 8: *for* 9850° *read* 9850

p. 274: formula IV *should read* $C_6H_5.CH_2.CO.(CH_2)_2.\underset{\displaystyle R}{\overset{\displaystyle R}{\overset{|}{\underset{|}{C}}}}—COOEt$

ENERGY BALANCE OF AND EVAPORATION FROM SWEET WATER LAKES OF THE JORDAN RIFT

J. NEUMANN

Meteorological Service, Israel Ministry of Transport

SUMMARY: The paper presents the results of energy-balance calculations for determining the evaporation from the two sweet water lakes of the Jordan Rift. The results are as follows:

1) Annual amount of evaporation ($\pm\sim 15\%$): Lake Tiberias: 162 cm; Lake Hula: 168 cm.

2) Annual variation of evaporation: Lake Tiberias: Double wave. Principal minimum in May, secondary minimum in January: principal maximum in October (month somewhat uncertain), secondary maximum in March. Lake Hula: Single wave. Minimum in December, maximum in July.

1. INTRODUCTION

1.1 *Method, notation and basic equations*

The present study is a summary of energy balance computations for the two sweet-water lakes of the Jordan Rift. The principal purpose is to determine as closely as possible the average annual evaporation as well as the annual variation of evaporation from each of the two lakes.

If we denote by

Q_e heat lost by evaporation (loss of latent heat) to the atmosphere, Q_w heat advected out of the lake by the mass of evaporated water, Q_c heat lost by conduction (loss of sensible heat) to the atmosphere, Q_s insolation arriving at the lake surface, r_s fraction of insolation reflected from the lake surface, Q_b effective back radiation from the lake surface to the atmosphere, Q_ϑ heat used to warm the waters of the lake; this term is usually referred to as change in heat storage of the lake, Q_g heat conducted from lake bed, Q_v heat advected in by streams, springs and underground seepage,

then the principle of conservation of energy applied to the lake states that for a given period, changes in the various energy terms must balance, or

$$Q_e + Q_w + Q_c = Q_s - r_s Q_s - Q_b - Q_\vartheta + Q_g + Q_v . \qquad (1.1)$$

It is customary to relate the various energy terms to a unit area of the surface of the lake. Eq. (1.1) may be thought of as conforming with this practice. It is also noted that in the equation the terms are grouped in such a way as to keep on one side terms representing energy interchange between the lake and the atmosphere by way of conduction and convection which are of primary interest for the present paper*.

* In hilly country such as the surroundings of Lake Tiberias, there is also a radiative interchange between the lake surface and the hills. However, because of the small solid angles involved, this interchange may be expected to be quite small. Similarly, energy interchanges connected with biological and chemical processes within the lake are also believed to be of no consequence.

Received September, 1952.

If we write

$$Q_s - r_s Q_s - Q_b = Q_r, \tag{1.2}$$

then Eq. (1.1) takes the form

$$Q_e + Q_w + Q_c = Q_r - Q_\vartheta + Q_g + Q_v. \tag{1.3}$$

Q_r is the net radiation surplus at the lake surface. Throughout this paper, the Q's are in gcal/cm^2.

It is assumed that Bowen's ratio R (Bowen 1926), which is the ratio of the sensible to latent heat losses to the atmosphere, can be computed as follows:

$$\frac{Q_c}{Q_e} = R = 61 \cdot 10^{-5} \frac{T_w - T_a}{e_w - e_a} p, \tag{1.4}$$

where the coefficient 61 has been chosen to be intermediate between its value appropriate to a hydrodynamically smooth and a hydrodynamically rough water surface. T_w and T_a are the lake surface and air temperature respectively, e_w is the vapour pressure of the lake surface, e_a the vapour pressure of the air at the height where T_a is measured, and p is the atmospheric pressure: T_w and T_a are in °C, e_w, e_a and p in *mb*. The dimension of the coefficient is deg^{-1}. For a derivation of the ratio R, as well as for a discussion of the problems connected with it, reference is made to literature.

For computing Q_w, the energy advected out of the lake by the mass of evaporated water, it is necessary to refer the energy content of the water to some base temperature (Anderson 1952, p. 72). The energy content of a unit mass of water may be written

$$c\ (T - T_b) + \text{const.} = T - T_b + \text{const.}, \tag{1.5}$$

the specific heat c of water having been taken as unity on the right hand side. In this equation, T is the temperature of water in °C and T_b is the selected base temperature, also in °C. The constant depends on T_b. If the water mass of the lake remains constant, then for any processes of *change* in energy content, the constant of Eq. (1.5) cancels out. In that case,

$$Q_w = c \varrho E\ (T_w - T_b), \tag{1.6}$$

ϱ being the density of the evaporating water, in g/cm^3, E the depth of the layer of water evaporated, in cm, during the period in question and T_w the lake surface temperature at which the evaporation, may be assumed to occur. If L is the latent heat of vaporization, in gcal/g, at the temperature T_w, then

$$E = \frac{Q_e}{\varrho L}. \tag{1.7}$$

Hence, Eq. (1.6) may be re-written

$$Q_w = \frac{Q_e}{L}\ c\ (T_w - T_b). \tag{1.8}$$

If Eq's (1.7) and (1.8) are substituted into Eq. (1.3), it is found that

$$Q_e = \frac{L\,(Q_r - Q_\vartheta + Q_g + Q_v)}{[L\,(1+R) + c\,(T_w - T_b)]},$$

and in view of Eq. (1.7),

$$E = \frac{Q_r - Q_\vartheta + Q_g + Q_v}{\varrho\,[L\,(1+R) + c\,(T_w - T_b)]}. \tag{1.9}$$

Throughout this paper, ϱ and c will be taken as unity.

It is pointed out by Anderson and Saur (Anderson 1952, pp. 72—73) that in the case of lakes of variable mass (~ volume), the change in energy content is not independent of the selected base temperature T_b but the error may be minimized by selecting T_b as the best temperature estimate of the

largest unknown advected volume such as seepage or precipitation. Now, in the case of precipitation, its temperature is roughly that of the wet-bulb temperature of the air. As to the temperature of seepage water for Lakes Tiberias and Hula, well temperatures in Israel may probably serve as indicators. In either case, $T_w - T_b$ appears to be of the order of 10°C. In computing evaporation in Table IV (Lake Tiberias) and in Table VIII (Lake Hula), we shall take $T_w - T_b = 10$. Numerically, this figure is less than 2 per cent of the value of $L(1 + R)$ in the denominator of (1.9).

1.2 *General remarks concerning the radiation calculations for the lakes*

For both lakes, the radiation terms are computed below by empirical equations. A brief listing of the computation methods adopted follows:

Insolation, Q_s: As described in Klein's (1948) summary. To correct for cloudiness, the value of insolation Q_o from a cloudless sky was reduced by Angstroem's formula

$$Q_s = Q_o\ (1 - 0.071\ C); \tag{1.10}$$

C being the cloud amount on the scale 0 to 10. All meteorological data involved in the computations are found in Table II for Lake Tiberias and in Table V for Lake Hula.

Some basic geophysical data are needed for the computations. The first concerns monthly amounts of solar radiation reaching the top of the atmosphere. These were conveniently computed by Bessel's interpolation from Shaw's (1936) data for latitudes 30° and 40° N. The second concerns mean monthly solar air mass values which have been obtained by interpolation from Kennedy's (1949) figures for 30° and 35° N. Computed data are as follows:

TABLE I

Monthly amounts of solar radiation (I_o) *in gcal/cm² arriving at top of the atmosphere and mean monthly solar air mass values* (m) *for* 33°*N.*
(*Values of solar radiation rounded off to nearest multiple of* 50; *air mass values correspond to a surface pressure of* 1,000 *mb*).

	I_o	m		I_o	m
January	14,350	4.0	July	29,700	2.9
February	16,200	3.5	August	27,550	3.0
March	22,500	3.2	September	23,200	3.0
April	25,700	3.0	October	19,350	3.3
May	29,300	2.9	November	14,800	3.8
June	29,300	2.9	December	13,250	4.1
			Sum	265,200	

Insolation reflected from the lake surface, $r_s Q_s$: It follows from a theoretical discussion, based on Fresnel's equations, by Lauscher (1952) of the reflection of insolation, i.e. of sun and sky radiation from a water surface, that for noon solar zenith distances $\varphi - \delta$ (φ = latitude, δ = solar declination) of between 0° and about 35°, the reflectivity for the *daily amounts* of *sun* radiation is very nearly constant, whereas for $(\varphi - \delta) > 35°$, the reflectivity increases at greater and greater rates. For $\varphi = +33°$, the approximate latitude of Lakes Tiberias and Hula, the reflectivity of sun radiation is about 0.04 (Lauscher, 1952, Figure 7) in spring, summer and autumn while reflectivity rises to its peak of *ca* 0.08 at the winter solstice.

As to the diffuse *sky* radiation, it shown by Lauscher that for a sky of uniform brightness, theory predicts a reflectivity of 0.066, but if the brightness increases from zenith to horizon, then reflectivity increases to a theoretical maximum of 0.177 which presumably may be realized under a cloud deck of rather low base and low solar altitudes. The values of reflectivity measured by Powell and Clarke (1936) and by Neiburger (1948) fall between the above limits but nearer to the lower limit than to the upper limit.

In the case of a broken or scattered sky, clouds increase the share of diffuse sky radiation in insolation. Anderson (1952) has considered the effects of low and high clouds upon the reflectivities of sun and sky radiation from a water surface using the data obtained at Lake Hefner ($\varphi = 35°30'$). In fair agreement with Lauscher's theoretical results and the theoretical and observational results of the Lake Hefner Studies, the value of reflectivity of sun and sky radiation at Lakes Tiberias and Hula has been taken to be 0.06. A slight annual variation of this value would have been more appropriate, but in view of the small range of variation apparent and in view of the limited accuracy attainable from computational procedures of insolation, it did not seem warranted to let the reflectivity values vary.

Effective back radiation from the lake surface, Q_b: This term is the balance of three component terms: (i) Long wave radiation from the lake surface in accordance with Stefan-Boltzmann's law corrected by an emissivity coefficient ε of water appropriate for the temperature range; (ii) atmospheric radiation Q_a, and (iii) atmospheric radiation reflected from the lake surface $r_a Q_a$, where r_a is the albedo of the lake surface for long-wave radiation. Since the atmosphere radiates at a temperature approximately the same as that of the water surface, we may take $r_a = 1 - \varepsilon$. The recent Lake Hefner investigations have found (Anderson 1952, pp. 96—98) by experimental work in the laboratories of the University of California, that in the water temperature range 0 to 30°C, $\varepsilon = 0.97$, very closely, and therefore, $r_a = 0.03$, to a good approximation. Hence, if T_w is the lake surface temperature, now in °K, then the effective back radiation Q_{bo} to a cloudless sky is represented by

$$Q_{bo} = \varepsilon\sigma T_w^4 - Q_{ao} + 0.03\ Q_{ao}, \qquad (1.11)$$

$$= 0.97\ (\sigma T_w^4 - Q_{ao}),$$

σ being the Stefan-Boltzmann constant for black-body radiation ($\sigma = 8.26 \times 10^{-11}$ gcal/cm²min.deg⁴) and Q_{ao} the value of Q_a for a cloudless sky. It is noted that a theoretical derivation (Lauscher 1952), based on Fresnel's equations, yields for the emissivity of water $\varepsilon = 0.9535$. Compared with the experimental result, the theoretical value is slightly low. In the infrared section of the long-wave radiation, however, the emissivity is somewhat greater, moreover, the reflection does not obey Fresnel's equations exactly. It may be said, therefore, that theory and experiment are in fair agreement.

During the last 15 years, evidence has accumulated that earlier measurements of atmospheric radiation and empirical methods for computing the same, based on these experimental results, yielded somewhat low values. Thus, Kruegler (1937) found that Angstroem's formula

$$Q_{ao} = \sigma T_a^4\ (a - b.10^{-ce}), \qquad (1.12)$$

where T_a is the air temperature in °K, e the vapour pressure of air, while a, b and c are empirical constants, yields amounts which are about 5 per cent lower than the amounts measured by him by means of both Angstroem's and by Falckenberg's pyrgeometers. Bolz and Falckenberg (1949) using new instrumentation, have re-determined the constants in Eq. (1.12) for a fairly wide range of values of vapour pressure. Their work also has indicated that the earlier measurements by Angstroem are slightly low. A similar trend can be noted in the observations conducted at Lake Hefner (Anderson 1952, p. 93).

In computing Q_{ao} for Lakes Tiberias and Hula, we have used Bolz and Falckenberg's (1949) curve for average atmospheric turbidity. Having then obtained Q_{bo} from Eq. (1.11), this was corrected for cloudiness in accordance with Lauscher's (1928) results. All meteorological data involved in the calculations can be found in Tables II and III (Lake Tiberias) and Tables V and VI (Lake Hula) respectively.

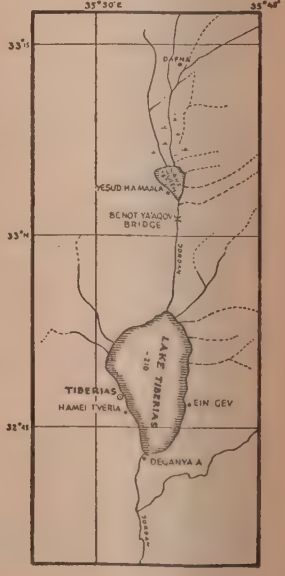

Figure 1

The Upper Jordan Rift. The map shows the location of stations data of which have been used in connection with the computations reported on in the present paper. Ramat David is outside the map; this station is situated some 35 km to the southwest of Lake Tiberias.

Scale: 1 : 1,000,000

2. LAKE TIBERIAS

2.1. *Basic data*

2.11 *Physiographic data*

Centre coordinates: 32°48'N, 35°35'E; Altitude: —210 m M.S.L.; Area: 167 km^2; Volume: 4×10^9 m^3; Average depth: 24 m; Maximum depth: about 50 m.

2.12 *Meteorological data used in computations*

In the absence of meteorological observations conducted for a sufficiently long period over the lake itself, recourse had to be taken to data of stations situated near the lake. An error is thereby introduced in the calculations, but the only computed quantity which is seriously affected is Bowen's ratio R (see Eq. (1.4)). However, in computations of evaporation by the energy balance method, Bowen's ratio takes the role of a correction factor whose value is relatively small. Any error in its value cannot seriously affect the value of computed evaporation.

The meteorological data used are partly those of Deganya A, but for cloudiness the averages of Deganya A and Tiberias, Forest Nursery Station, were taken. The latter lies about 100 m above the lake and offers a relatively good view of cloudiness over the lake. Pressure data are also from the Nursery Station, the values being reduced to lake level.

TABLE II

Monthly meteorological data for Deganya A and for Tiberias Forest Nursery Station

	J	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*Average*
Deganya A (—200m M.S.L.; 32°43'N, 35°34'E), 1945—49													
Air temperature °C	13.8	13.6	15.1	18.9	25.2	27.2	29.8	30.2	28.1	24.8	21.4	16.0	22.0
Vapour pressure of air, mb.	11.2	11.8	12.2	14.0	17.3	19.5	23.9	24.9	21.7	16.3	14.3	12.6	16.6
Cloud amount, tenths	4.8	4.6	4.4	3.4	3.5	1.0	0.9	1.1	1.2	1.8	3.2	4.5	2.9
Tiberias, Forest Nursery Station (—110m M.S.L.; 32°48'N, 35°32'E), 1941—50													
Cloud amount, tenths	5.4	4.7	4.7	3.1	2.9	1.2	1.2	1.2	1.2	2.6	4.0	5.0	3.1
Pressure, 1000 + mb reduced to lake level	44	43	42	39	36	34	30	31	35	41	42	44	38
Average of Deganya A and of Tiberias, Forest Nursery Station													
Cloud amount, tenths	5.1	4.7	4.5	3.3	3.2	1.1	1.1	1.1	1.2	2.2	3.6	4.7	3.0

2.13 *Lake temperature data*

Ashbel's (1945) table of the annual variation of temperature with depth in the lake, based on measurements taken in 1943—45 near Ein-Gev, Hamei T'verya and various points in the lake is as follows:

TABLE III

Annual variation of temperature with depth for Lake Tiberias (after Ashbel) and saturation vapour pressure at temperature of lake surface, (°C)

Depth (m)	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*Average*
0	17.0	15.0	16.3	21.0	24.4	26.8	28.5	29.5	29.5	27.7	23.9	21.5	23.4
10	15.9	15.0	15.4	16.0	20.8	26.6	28.0	29.4	29.1	27.3	23.5	17.5	
20	15.0	15.0	15.0	15.0	16.7	20.8	26.0	27.0	27.0	25.0	18.0	15.4	
30	15.0	15.0	15.0	15.0	15.0	15.2	15.7	15.7	15.4	15.2	15.5	15.5	
40	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	
Vapour pressure of the lake surface, mb	19.4	17.1	18.5	24.9	30.6	35.3	39.0	41.3	41.3	37.2	29.7	25.7	

Lake surface temperatures are required for computations of the effective back radiation from the lake surface. Data of temperature and vapour pressure of the lake surface enter calculations of the Bowen ratios. Depth temperatures are used to evaluate the monthly amounts of heat which go into storage or which are released from storage in the lake.

A somewhat unusual feature of the annual variation of lake temperatures as given above is the late date of beginning of the cooling process in autumn. A consequence of this feature is, as will be seen below, that the computations indicate the principal maximum of evaporation to occur as late as October.

2.2 *Computation of terms of the energy balance of Lake Tiberias*

In this Section, a brief description will be given of the method whereby each term of the energy balance is computed. Results are tabulated in Table IV.

2.21 *Net radiation surplus:* $Q_r = Q_s - r_s Q_s - Q_b$.

For method of computation see statement in Section 1.2. The results in Table IV indicate an annual amount of insolation of 177,000 gcal/cm^2 reaching the lake surface. For comparison, according to Ashbel's (1942) measurements, the average (10 years) annual amount of insolation at Mt. Scopus (830 m), Jerusalem, is 185,000 gcal/cm^2.

A noteworthy feature of Table IV is the decrease from spring to summer of values of the effective back radiation, despite increasingly clear skies (Table II). The reason for this is in that the temperature and vapour pressure of the air which enter the calculation of atmospheric radiation ("counter radiation"), increase from spring to summer at a greater rate than the lake surface temperature which determines the long-wave radiation from the water (see Eq. (1.11)).

2.22 *Changes in heat storage:* Q_ϑ.

These have been computed from Ashbel's table of water temperatures (Table III) above. The figures indicate an annual heat budget of approximately 33,500 gcal/cm^2.

This value of the annual heat budget is close to the values found (Welch, 1935, p. 61) for other extra-tropical lakes.

2.23 *Heat conducted into and from lake bed:* Q_g.

Ashbel's figures indicate that the annual temperature variation below about 25 m (the approximate position of the thermocline base) is less than 1°C. More recent soundings of the lake by a cooperative project of the Sea Fisheries Research Station, the Hydrological Service and the Division of National Irrigation and Power Plan, all of the Ministry of Agriculture and Development, indicate a slightly larger range, approximately 2°C, but even that range makes it improbable that any important amounts of heat will be conducted in or out of the lake bed under the deeper part of the lake.

According to the same soundings, the 25 m isobath contains about two-thirds of the surface area of the lake (map in paper by de Leeuw, 1950), so that for the greater part of the lake the term Q_g may be considered negligible. As to the shallower sections underneath the remaining one-third of the surface, Q_g will not be negligible. Data on hand are insufficient for a satisfactory quantitative treatment of the problem. It appears probable, however, that for the shallower sections of the lake the values of Q_ϑ in Table IV are somewhat large, even though the smaller depths are partly compensated by larger temperature ranges. The values of Q_ϑ are expected to make up to some extent for the neglected values of Q_g. In this connection, it may be pointed out that the lake bed can be considered as an extension of the lake (Bowden 1948) which in effect increases the thermal capacity (= depth) of the lake. A discussion of the role of lake beds and in particular that of Lake Hula will be given in Section 3.23.

2.24 *Energy advected in and out by streams and springs:* Q_v.

Energy advected in and out by the Jordan. The Hydrological Service has made available monthly averages of the Jordan's discharge at Benot Ya'aqov Bridge, 15 km north from the point of inflow of the river to the lake and at the Deganya Dam, at the point of exit. A consideration of these data in conjunction with figures of lake temperature changes shows that energy advection by the Jordan, when related to a unit surface area of the lake, is very small. The maximum monthly figure is about 100 gcal/cm^2 which if all used for evaporation, would amount to an evaporation of 0.17 cm. The result is not unusual. Advective terms are large either in the case of shallow and small lakes where stream, seepage, and spring inflow (or stream and seepage outflow) is great relative to volume of the lake or where waters of a notably different temperature are advected in sufficiently large masses to the lake (or sea). It will be seen in Section 3 that the advective term is of some importance for Lake Hula. The following section will illustrate the smallness of energy advection by hot springs.

Energy advected in by hot springs. The temperature of these springs is about 60°C, or nearly 40°C higher than the average temperature of the lake. However, the annual discharge of the hot springs is only *ca* 10^6 m^3, or 4,000 times less than the volume of the lake. Adopting a 40°C temperature difference, energy advection by hot springs would amount to 4×10^7 gcal yearly. If this is related to the surface area of the lake (167×10^{10} cm^2), we find that the annual contribution is 2.5×10^{-5} gcal/cm^2. Energy advection by hot springs is thus negligible.

Energy advected by the known "non-hot" springs and by underground in seepage and out seepage. According to data supplied by the Hydrological Service, the average annual inflow into the lake from the known "non-hot" springs amounts to some 65×10^6 m^3. Very little is known about subsurface springs and about in and out seepage but some workers believe that the in seepage is of some importance. For instance, a rough estimate (Neumann and Rosenan 1953) of the water balance of the catchment area would indicate that the annual in seepage may amount to a few tens of million of cubic metres and that the out seepage is likely to be small. Some of the subsurface inflow, if any, might originate from hot springs but because of the rather normal temperature conditions of the lake, it is improbable that subsurface hot springs owe any share of importance in the heat balance of the lake. For the sake of argument we shall assume that (i) the total annual discharge by the "non-hot" surface springs and unknown subsurface springs or in seepage is, say, 10^8 m^3, and (ii) the temperature difference between these waters and the lake is 10°C throughout the year. In that case, the annual heat advection by these sources would amount to 10^{15} gcal which related to a unit area of the lake surface is about 600 gcal/cm^2. Neglect of this amount would be equivalent to an underestimate (or an overestimate, depending on the sign of the temperature difference) of the annual evaporation by 1 cm.

Although the contents of the foregoing paragraph are highly speculative, they probably correctly indicate that the contribution of the sources considered above is unimportant for the heat budget and evaporation from the lake as a whole.

2.25 *Energy exchanged with the atmosphere by convection and conduction:* Q_e (= *latent heat*), Q_w (= *heat advected out of the lake by the mass of evaporated water and* Q_c (= *sensible heat*).

Since Q_g and Q_v have been found to be negligible in relation to other terms of the balance, the heat which is transferred to the atmosphere must be equal to the algebraic sum of the heat available at the sea surface from radiative sources and the heat used for warming the lake in the seasons of warming or released from it in the seasons of cooling. The first term is the net radiative balance Q_r (Section 2.21) at the sea surface, the second is Q_θ (Section 2.22). The general relationships involved have been discussed in Section 1.1.

The complete evaluation of all the terms can be found in Table IV.

2.3 *Discussion of the results of computations for Lake Tiberias*

The results (Table IV) show an annual evaporation of 162 cm. It is difficult to assess the accuracy of this figure but it is probably of the order of 15 per cent. It is noted that a small fraction of the heat expended on evaporation is derived from the air. This is indicated in Table IV by the negative Bowen ratios from May to August inclusive, implying that in these months, there is, on the average, net flow of sensible heat from the air to the lake.

The most surprising result is furnished by the annual variation of evaporation. According to Table IV, the absolute minimum of monthly evaporation occurs in May. Further, it is interesting to note that the absolute maximum of monthly evaporation occurs in autumn and not in summer. The form of the annual curve is a double wave

TABLE IV

Energy balance of Lake Tiberias (computed)

Term	*Discussed in Section*	*Symbol*	*Equation*	*Jan.*	*Feb.*	*March*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sep.*	*Oct.*	*Nov.*	*Dec.*	*Year*
Insolation (gcal/cm²)	2.21	Q_s		8,100	9,500	13,000	16,800	18,600	22,000	22,000	19,800	17,200	13,300	9,200	7,500	177,000
Insolation reflected from the lake surface (gcal/cm²)	2.21	r_sQ_s	$r=0.06$	500	600	800	1,000	1,100	1,300	1,300	1,200	1,000	800	600	500	10,700
Effective back radiation (gcal/cm²)	2.21	Q_b		5,700	3,900	4,500	5,200	5,100	5,000	4,800	5,500	5,800	6,100	6,000	5,800	63,400
Net radiation surplus (gcal/cm²)	2.21	Q_r	$=Q_s-r_sQ_s-Q_b$	1,900	5,000	7,700	10,600	12,400	15,700	15,900	13,100	10,400	6,400	2,600	1,200	102,900
Changes in heat storage in the lake (gcal/cm²)	2.22	Q_ϑ		−3,100	−400	2,000	5,200	9,600	9,500	5,400	1,800	−2,800	−8,900	−1,300	−7,000	0
Total heat available for transfer from the lake surface to the atmosphere (gcal/cm²)	2.25	Q_A	$=Q_r-Q_\vartheta$	5,000	5,400	5,700	5,400	2,800	6,200	10,500	11,300	13,200	15,300	13,900	8,200	102,900
Bowen's ratio	1.1	R	$=61.10^{-5}\frac{T_w-T_a}{e_w-e_a}p$	0.25	0.17	0.12	0.12	−0.04	−0.02	−0.05	−0.03	0.05	0.09	0.10	0.27	
Latent heat of vaporization (gcal/g)		L		588	589	588	586	584	583	582	581	581	582	584	586	
$L(1+R)+10$	1.1			744	699	669	668	572	584	559	575	617	643	654	751	
Evaporation* (cm)	2.3	E	$=\frac{Q_r-Q_\vartheta}{L(1+R)+10}$	6.5	7.5	8.5	8.0	5.0	10.5	18.5	20.0	21.5	24.0	21.5	11.0	162.5

*Values rounded off.

(see Figures 2 and 3). In this, the results show that evaporation from the lake possesses some of the chief characteristics of the annual evaporation from the seas and oceans in middle latitudes. There is, however, one important difference: for the seas and oceans of middle latitudes, the principal minimum of evaporation occurs in summer and the principal maximum in winter.

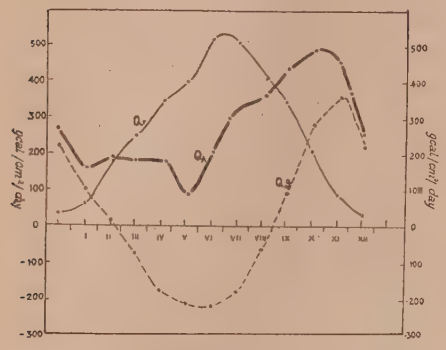

Figure 2

Energy balance of Lake Tiberias (computed). Legend: Q_r = net radiation surplus at the lake surface; Q_ϑ = heat used for warming (or cooling) the lake; Q_A = heat transferred from the lake surface to the atmosphere: $Q_A = Q_r - Q_\vartheta$.

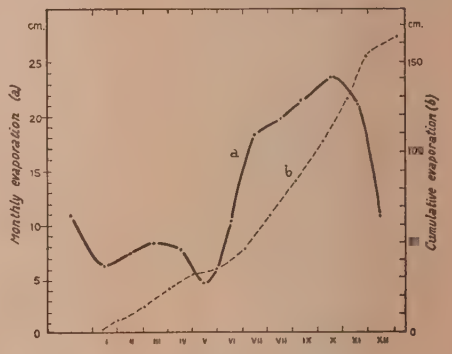

Figure 3

Lake Tiberias: Curve (a)—monthly amounts of evaporation (computed), left hand scale; curve (b)—cumulative evaporation (computed), right hand scale.

Table IV explains the above annual variation as the result of the great warming of the lake late in spring and its great cooling in autumn. The first withdraws heat from the finite amount of heat which is available for the lake both from radiative sources and also by conduction from the air, which in May becomes, on the average, warmer than the lake surface. The cooling process, on the other hand, adds heat to that available from radiative sources for transfer to the atmosphere.

An application of the more recent temperature soundings of the lake to which reference was made above, also shows the absolute minimum of evaporation to occur in spring but it does not confirm the late date of the principal maximum. The amount of annual evaporation obtained from energy-balance computations for the period of the new soundings (nearly two years) is quite close to the average value in Table IV. To sum up, we may consider the figure of annual evaporation as a reasonably close approximation of the annual average. The annual variation of evaporation appears to be a double wave whose two minima occur in winter and late in spring, respectively. One maximum (the secondary one) develops early in spring while the principal maximum occurs in autumn. Further soundings of the lake are needed to establish the annual variation in greater detail.

It has been suggested, that the frequent storms which occur almost daily in summer in the lake may be responsible for a large evaporation from lake spray. In this connection it is worthwhile to quote a statement by Jacobs (1951, p. 35) who sums up the present position of the problem of evaporation from sea spray as follows:

"Sverdrup (1943) has suggested that the application of Bowen's formula for R will be invalidated if the evaporation from the sea surface is greatly increased at wind velocities high enough to carry spray into the air ... Montgomery (1940)* considers this process of importance to the evaporation over the oceans, and states that under extreme conditions the quantity of water evaporated in the presence of spray may be several times that evaporated in the absence of spray.

McEwen (1936)* quotes a figure of 12.7 cubic miles of water per year as representing the total evaporation from sea spray over all oceans. This figure is based upon an examination of the sea-salt content of rain water. Since he gives a figure of 89,000 cubic miles of water per year as the total evaporation from all oceans, it follows that the proportion derived from sea spray is 0.0001. However, he does not give the source of these data or the method by which they have been obtained.

McEwen's data indicate that the evaporation from spray is unimportant. This conclusion is supported more recently by Sverdrup (1946), who, by means of comparison between the observed humidity gradients existing above the sea surface and those derived on the basis of theoretical considerations of the transfer of water vapour within the boudary layer, shows that the effect of evaporation from spray is relatively unimportant."

With regard to McEwen's estimate of the total amount of evaporation from all oceans, as quoted by Jacobs, the following may be added: McEwen's estimate is equivalent to a total evaporation of 365,000 km^3/year, while Wuest (Sverdrup *et al.*, 1946, p. 120) estimated the same at 334,000 km^3/year.** The agreement between the two estimates is better than 10 per cent. The fact that the two estimates had been arrived at by independent methods, lends partial support to McEwen's estimate of the order of magnitude of evaporation from sea spray.

3. LAKE HULA

3.1 *Basic data*

3.11 *Physiographic data*

Centre coordinates: 33°04'N, 35°38'E; Altitude: +67 m; Area: about 14 km^2; Volume: about 0.25×10^8 m^3; Average depth: about 1.70 m; Maximum depth: about 4 m.

3.12 *Meterological data used in computations*

In the absence of meteorological observations from above the lake itself, the data of Yesud Ha Ma'ala, Dafna and Ramat David were used. The first station is on the southwest coast of the lake and we have used its temperature and humidity data (Ashbel 1951, p. 222). Dafna is about 15 km north of the lake. It was the nearest station for which records of cloud amount were on hand. Values of atmospheric pressure have been obtained by reducing pressure observations of the station at Ramat David to the level of Lake Hula.

The effect on the results of computed evaporation of using meteorological data which are not from above the lake itself has been discussed briefly in Section 2.12 in connection with Lake Tiberias.

* For these references, see Jacobs, 1951.

** After writing up this study, Reichel's (1951) paper came to hand. Reichel reviews the estimates made by various investigators concerning the annual amount of evaporation from all oceans and seas. He concludes that by present knowledge, the best estimate appears to be 345,000 km^3/year. It is noted that this figure is intermediate between the above quoted two estimates.

TABLE V

Monthly meteorological data for Yesud Ha Ma'ala (after Ashbel), Dafna and Ramat David

	J	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*Average*
a) *Yesud ha Ma'ala* (+75m M.S.L.; 33°04'N, 35°37'E), 1935—45													
Temperature of air, °C	11.1	12.1	13.8	19.0	22.9	24.7	27.1	27.4	25.4	23.0	17.3	13.1	19.7
Vapour pressure of air, mb,	10.1	10.5	11.6	14.9	17.2	19.6	23.3	25.9	23.1	19.1	14.9	11.5	16.8
b) *Dafna* (+150m M.S.L.; 33°14'N, 35°38'E), 1947—50													
Cloud amount, tenths	4.3	5.0	4.7	3.2	2.7	0.4	0.4	0.8	1.1	1.4	3.9	4.2	2.7
c) *Ramat David* (+50m; 32°40'N, 35°11'E), 1944—46 and 1948—51													
Atmospheric pressure, 1000+mb, reduced to lake level	17	16	15	14	12	10	08	08	12	15	16	18	13

3.13 *Lake temperature data*

Ashbel (1945) has published monthly averages of lake temperatures for the period December 1938 to August 1945 taken near Yesud Ha Ma'ala. Ashbel (1951, p. 227) also points out that because of the shallowness of the lake, there is little difference between surface and bottom temperatures.

Table VI gives the water temperature data to which are added values of the saturation vapour pressure at the lake surface temperature. Both lake surface temperatures and vapour pressures at the lake surface are needed for the Bowen ratios, but the lake surface temperatures are also required for computations of the effective back radiation.

TABLE VI

Annual variation of temperature in Lake Hula (after Ashbel) and vapour pressure of lake surface

	J	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*Average*
a) Lake temperatures, °C,	13.4	14.5	16.4	20.7	23.7	25.8	26.5	27.1	26.1	23.6	19.3	17.8	21.2
b) Vapour pressure of the lake surface, mb.	15.4	16.5	18.7	24.4	29.3	33.3	34.7	35.9	33.8	29.2	22.4	20.4	

3.2 *Computation of terms of the energy balance*

As in the case of Lake Tiberias we will describe and, where necessary, discuss the method whereby each term of the balance is computed. The results are given compactly in Table VIII.

3.21 *Net radiation surplus:* $Q_r = Q_s - r_s Q_s - Q_b$.
For method of computation see statement in Section 1.2.

According to Table VIII, the annual amount of insolation reaching the surface of Lake Hula is 184,300 gcal/cm^2 against a value of 177,000 for Lake Tiberias. The net annual radiation surplus for Lake Hula is 110,000 gcal/cm^2 and only 102,900 for Lake Tiberias.

A question which was not important to be considered in connection with Lake Tiberias, concerns the amount of insolation which possibly re-emerges from the shallow Hula waters. In a turbid lake, the major part of insolation penetrating the lake surface is absorbed in a relatively thin top layer. Insolation which reaches the lake bottom without being absorbed by the intervening water layer, is partly absorbed by and partly reflected and scattered from the lake bed whose surface can be considered to be a near-ideal diffuse scatterer. In order to assess the fraction of insolation which possibly re-emerges from the lake, an argument put forward by Angstroem (1925, Lauscher 1952) will be followed with the difference that the extinction of radiation by the turbid water will be taken into account.

Let I be the insolation energy which crosses a unit area of the lake surface. Extinction in the turbid water will reduce the energy arriving at the lake bed to αI, $0 < \alpha < 1$. The lake bed absorbs a fraction of this and returns the remaining fraction a (a = albedo), $0 < a < 1$, of αI by diffuse reflection so that the energy reflected from a unit area of the lake bed will be $a\alpha I$. Part of the latter leaves the lake bed at angles (i) equal to or smaller than ψ' and the other part at angles (ii) greater than ψ', ψ' being the critical angle of total reflection at the water/air interface. Radiation (i) will be contained in a cone of width $2\psi'$ and its energy may be computed from Lambert's law which states that in the case of radiation diffusely reflected from a surface, the energy reflected in direction φ, measured from the normal to the surface, is a fraction $(\cos \varphi)/\pi$ of the energy reflected from the unit area concerned. Applying the law to the present case but disregarding momentarily the partial absorption of the reflected radiation by water, the energy reflected in direction φ is $(a\alpha I \cos \varphi)/\pi$. On the surface of a hemisphere the centre of which is in the middle of the unit area of the lake bed and the radius of which is r, a zone of infinitesimal width $d\varphi$ will receive the amount $(2\pi r \sin\varphi\, r d\varphi \cdot a\alpha I \cos \varphi)/\pi r^2 = 2\, a\alpha I \sin\varphi \cos\varphi\, d\varphi$. The total amount of radiation reflected in the cone $\leqslant \psi$ will be

$$a\alpha I \int_0^{\psi'} 2 \sin\varphi \cos\varphi \, d\varphi = a\alpha I \sin^2 \varphi$$

Taking into account extinction effects, the energy in the cone arriving at the lake surface will be $a^2\alpha I \sin^2\psi$ and this should re-emerge from the lake.

That part of the radiation which is diffusely reflected from the unit area of the lake bed at angles $> \psi'$ and which is totally reflected back into the lake at the water air interface is the complementary amount $a^2\alpha I\,(1 - \sin^2\psi')$. This will undergo now the same processes as did the radiation which first crossed the water. The fraction of it which will be reflected from the lake bed in the cone $< \psi'$ is $a^4\alpha^2 I\,(1 - \sin^2\psi').\sin^2\psi'$, etc. Thus, in assessing the re-emergent radiation we are led to an infinite geometric progression

$$a^2\alpha I \sin^2\psi + a^4\alpha^2 I\,(1 - \sin^2\psi) \sin^2\psi + \ldots\ldots$$

whose sum is

$$\frac{a^2\alpha I \sin^2\psi}{1 - a^2\alpha\,(1 - \sin^2\psi)}.$$

For the case of water/air, $\sin\psi' = 0.75$. The albedo measurements by Angstroem (1925, p. 332) gave for wet sand $a = 0.09$ and for wet black mud $a = 0.08$, and therefore we shall adopt $a = 0.1$ for the lake bed. In regard of α, the extinction coefficient, we note that the measurements of Birge and Juday (quoted by Sverdrup *et al.*, 1946, p. 108, diagram) in four different lakes in the United States indicate the average percentage of energy of radiation on all wave lengths reaching a depth of 1.70 m,

which corresponds to the average depth of Lake Hula, to be about 17 per cent of the total energy penetrating the lake surfaces. If we exclude the results for one lake (Lake Crystal) whose waters appear to be far less turbid than those of Lake Hula, the average is 13 per cent.

It will be assumed that the appropriate figure for Lake Hula is 15 per cent, or $\alpha = 0.15$. With $a = 0.1$ and $\sin \psi = 0.75$, it is found from the sum of the geometric progression that the re-emergent radiation is less than one one-hundredth of one per cent of the radiation penetrating the surface of Lake Hula. It might be added that we have not considered above the fact that a small percentage of the radiation reflected from the lake bottom within the cone $< \psi$ is specularly reflected (= partial reflection) from the water surface back into the lake so that the energy re-emerging from the lake is even smaller than the amount cited above.

3.22 *Changes in heat storage:* Q_ϑ.

We have assumed that the average depth of the lake is 1.75 m in the rainy season and 1.60 m in the dry season. Further the temperature figures in Table VI have been assumed to be representative for the whole depth of the shallow lake. From data of monthly temperature changes of the lake and data for the depth of the lake, one can compute Q_ϑ (Table VIII).

3.23 *Heat conducted into and from lake bed:* Q_g.

The temperature of the lake bed surface will, to an approximation, vary as the temperature of the bottom waters of the lake. Heat will be conducted into it in spring and summer and released from it in autumn and winter. In this respect, the lake bed behaves very much like the waters of the lake themselves, the main difference being that the times of extremes of heat content in the bed soil will "lag" upon times of the correponding extremes of the lake waters. Like for the lake waters, one may assume for the lake bed that, under average conditions, the same amount of heat will be given up between summer and winter as went into storage between winter and summer.

It was pointed out by Bowden (1948), in connection with a section of the Irish Sea, that the effect of the sea bed is to increase the apparent thermal capacity of the sea, the apparent increase for the Irish Sea amounting to a depth of water of 1 m. He arrived at this by assuming the annual variation of temperature of the sea bed to be a simple sine wave and then estimating the amplitude of the alternating part of the heat content of the sea bed.

Since Lake Hula is a shallow lake, one cannot presume the heat entering or leaving its bed to be of negligible importance for the energy balance of the lake. As in the case of all other energy terms, Q_g will be computed for monthly periods. For that purpose the following notation will be employed:

T—alternating part of the annual temperature wave of the lake bed in °C; z—depth below lake bed surface in cm; positive downward; T_z—T at depth z; T_o—T at lake bed surface ($z = 0$) or alternating part of annual temperature wave of the bottom water; t—time in sec; $t = 0$ at 00 hr Local Mean Time on January 1: a_n—harmonic coefficient of n^{th} Fourier wave of T; A_n—phase angle of n^{th} Fourier wave of T; ω—2π/year or $(2\pi/3.16 \times 10^7)$ sec^{-1}; K—thermal diffusivity of lake bed in cm^2/sec; c—heat capacity of lake bed in gcal/g/deg; ϱ—density of soil of lake bed in g/cm^3; a—$\sqrt{\omega/2K}$. Q^*_g—alternating part of heat content of the lake bed for a *yearly cycle.*

We will consider the lake bed to have a thermal diffusivity K which is constant with depth. The fact is hardly disturbing that underneath the soft mud which forms the upper layer of the lake bed, clay

or other substances are found. The mud layer is several meters deep; there are well-known theoretical reasons for assuming that the amplitude of the annual temperature variation will be very small at some depth below the mud surface. On the observational side, one may quote the measurements conducted by Birge and Juday (Welch, 1935, p. 66) in the bottom deposit of Lake Mendota, Wisconsin. At one station which was 8 m below water surface, the surface temperature of the lake bed mud was 2.3°C on December 15 and 22.3°C on August 1. At depth of 5 m in the mud, the corresponding temperatures were 10.6° and 9.4°.

In order to arrive at an estimate of the heat amounts which enter or leave Lake Hula's bed, we first analyze harmonically the annual variation of water temperatures stated in Table VI. It is supposed that this also represents the variation of the surface temperature T_o of the lake bed.

Harmonic analysis of the annual variation of lake water temperature, carried to the fourth wave, yields for the form

$$T_0 = \sum_{n=1}^{4} a_n \sin (A_n + n\omega t), \tag{3.1}$$

the following harmonic constants:

$a_1 = +6.56°C$	$A_1 = 240°42'$	$p_1 = -5.72°C$	$q_1 = -3.21°C$
$a_2 = 0.85$	$A_2 = 212°41'$	$p_2 = -0.46$	$q_2 = -0.72$
$a_3 = 0.36$	$A_3 = 107°56'$	$p_3 = +0.34$	$q_3 = -0.11$
$a_4 = 0.29$	$A_4 = 152°55'$	$p_4 = +0.13$	$q_4 = -0.26$

(3.2)

We have also added the constants of the form

$$T_0 = \sum_{n=1}^{4} (p_n \cos n\omega t + q_n \sin n\omega t) \tag{3.3}$$

for the convenience of harmonic synthesis. The constant term is 21.24°C (average yearly lake water temperature, Table VI). Application of the "completeness criterion" to the representation under Eq. (3.1) gives 0.5 per cent which indicates a close approximation of the observed annual variation. Eq.'s (3.1) and (3.3) are equivalent forms.

If conduction of heat in the lake bed is purely molecular, then the function describing the annual variation of temperature with depth in the lake bed whose thermal diffusivity K is assumed to be constant, will be given by solution of the differential equation of heat conduction in solids:

$$\frac{\partial T}{\partial t} = K \frac{\partial^2 T}{\partial z^2}, \tag{3.4}$$

satisfying the following boundary conditions:

(i) for $z = 0$, or at top of lake bed:

$$T_0 = \sum_{n=1}^{4} a_n \sin (A_n + n\omega t);$$

(ii) for $z \to \infty$, $T_z \to 0$,

T_z (as well as T_0) denoting the alternating part of the solution.

The appropriate solution of Eq. (3.4) with the above boundary conditions, is well known from the theory of conduction of heat in solids:

$$T_z = \sum_{n=1}^{4} a_n e^{-\sqrt{n}\,az} \sin (A_n + n\omega t - \sqrt{n}\,az). \tag{3.5}$$

The alternating part of the heat content Q_g^* will be obtained by multiplying T_z by c_ϱ, the specific heat per unit volume of lake bed, and then integrating the product in respect of z. If we assume c_ϱ to be constant with depth, then

$$Q_g^* = c_\varrho \int_0^\infty T_z \, dz. \tag{3.6}$$

$$= \frac{c_\varrho}{\sqrt{2}a} \sum_{n=1}^{4} \frac{a_n}{\sqrt{n}} \sin (A_n + n\omega t - \frac{\pi}{4}). \tag{3.7}$$

Eq. (3.7) may also be written in the following form which can be more readily evaluated:

$$Q_g^* = \frac{c_\varrho}{2a} \sum_{n=1}^{4} \frac{a_n}{\sqrt{n}} \left[\sin (A_n + n\omega t) - \sin (A_n + \frac{\pi}{2} + n\omega t) \right]. \tag{3.8}$$

By harmonic synthesis we can find the value of the expression under the summation symbol of Eq. (3.8). The constants needed for the synthesis can be found under Eq. (3.2) above. Table VII states the values of the expression for the 1st day of each month; row 2 gives the monthly changes of the same values:

TABLE VII

The function $\sum_{n=1}^{4} \frac{a_n}{\sqrt{n}} \left[\sin (A_n + n\omega t) - \sin (A_n + \frac{\pi}{2} + n\omega t) \right]$

J	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*
Value of function on 1st day of month $(2aQ_g^*/c_\varrho)$											
−1.87	−7.28	−10.11	−9.04	−5.75	−1.38	+2.63	+5.72	+8.39	+9.08	+6.67	+2.94
Monthly change of value of the function $(2aQ_g^*/c_\varrho)$											
−5.41	−2.83	+1.07	+3.29	+4.37	+4.01	+3.09	+2.67	+0.69	−2.41	−3.73	−4.81

To obtain the monthly changes of heat content of the lake bed, the values in row 2 of Table VII have to be multiplied by the constant factor $c_\ell/2a$, c_ϱ being the specific heat per unit volume of the lake bed substance. In the case of soft mud mixed with some sand the value of c_ϱ will be about 0.7 cal/cm^3 deg. Further, $a = \sqrt{\omega/2K}$. K for soft mud is about 3.25×10^{-3} cm^2 sec^{-1}. Since the bottom mud is locally admixed with some sand, we suggest to take for K the value of 4×10^{-3}: the thermal diffusivity of wet sandy soil is greater (Geiger, 1950, p. 29). Lastly, $\omega = (2\pi/3.16 \times 10^7)$ sec^{-1} or approximately $= 2 \times 10^{-7}$. Thus one finds $a = 0.5 \times 10^{-2}$ and $c_\varrho/2a = 70$. If one multiplies by that value the figures in row 2 of Table VII and if the products are rounded off to the nearest multiple of 100, then the values in Table VIII in the row for Q_g are obtained. In that table the values of Q_g are entered with opposite signs to those of the corresponding terms in Table VII. When, viz., the heat content of the lake bed increases, the change is negative from the point of view of the energy interchange with the atmosphere.

The results in Table VIII indicate that the lake bed has a heat budget of approximately 1,400 gcal/cm^2. According to Ashbel's data, the lake has an annual temperature range of about 13°C (Table VI). If we divide by the value of the temperature range the figure for the lake bed heat budget, the apparent increase of thermal capacity of the lake by the lake bed is obtained. It is thus found that the effect of the bed is to increase the thermal capacity of the lake by that of a layer of water about 1.05 m deep. The average depth of the lake being some 1.70 m, it results that the lake and its bed have an apparent overall thermal capacity of a water layer of 2.75 m.

3.24 *Heat advected in and out of the lake by the Jordan:* Q_v.

We have computed the energy advected out of the lake by the effluent Jordan with the help of (a) data supplied by the Director of the Hydrological Service and (b) water temperature data in Table VI. The former data refer to the Jordan's discharge at Benot Ya'aqov Bridge, about 4 km south of the river's exit from the lake.

In passing through Lake Hula, the waters of the Jordan mix, presumably, with the waters of the lake. Water which flows out of the lake in the seasons when the lake warms up, exports heat, which, had it been left in the lake, would have been transferred to the atmosphere in due course. The Bowen ratios in Table VIII indicate that a good part of that heat would have served to increase evaporation from the lake. Water which flows out of the lake during the cooling season but before that season is up, would have, had it remained in the lake, released heat to the atmosphere and thereby promoted evaporation. It is therefore suggested that the Jordan's outflow represents an energy loss for the lake (although a conservation of water for the economy of the country) and therefore, the term representing the outflow in the energy balance, carries a minus sign throughout the year.

As to the numerical values of the monthly Q_v's, they depend both on the magnitude of the Jordan's outflow and on the temperature change of the lake's waters. If M is the volume of water drained by the Jordan in the course of a month, related to a unit surface area of the lake, and $\triangle T$ is the change of the average temperature of the lake in the same month, it is suggested that the most probable numerical value of Q_v is

$$Q_v = M|\triangle T|/2.$$

Computations carried out in agreement with the foregoing paragraphs indicate that the largest value of Q_v occurs in March when it amounts to —1,200 gcal/cm^2. Although the mass of water transported out of the lake in March is about 15 per cent less than in February, the maximum value of Q_v in March is due to the large value of $\triangle T$ in the same month. According to Ashbel's data (Table VI), the greatest rate of warming of the lake occurs in March.

The total yearly amount of Q_v for the effluent Jordan is —4,500 gcal/cm^2 (Table VIII) which, if fully used for evaporation, would be equivalent to an evaporation of about 7.5 cm.

We are unable to compute the energy advection by the affluent Jordan, data needed for that purpose not being available. It is noted, however, that in view of smallness of the lake, the magnitude of the combined Jordan, springs and underground seepage inflow can not be much larger than that of the Jordan outflow. The present energy balance computations result in an annual evaporation of about 168 cm which related to a lake surface area of 14 km^2, amounts to about 0.23×10^8 m^3/year. According to the average rainfall map published in "Climatological Normals" (Part I, 1952), the isohyet 50 cm crosses the lake or about 0.07×10^8 m^3/year of water is supplied to the lake by precipitation, leaving a net loss of water of 0.16×10^8 m^3/year. It is by this amount that the total inflow by the Jordan, springs and seepage must exceed the total outflow. Since it is reasonable to assume no underground losses from the lake, the total outflow is represented by the Jordan's discharge at its exit. This discharge

amounts to approximately 5.5×10^8 m^3/year so that the computed *excess* of inflow, other than rain, is only about 3 per cent of the measured outflow.

The magnitude of the energy inflow will also depend on the temperature difference between the inflowing waters and that of the lake. Ashbel states (1951, pp. 227—8) that the waters of the Hula swamps (just north of the lake, see figure 1) through which flows the Jordan, are warmer in winter and colder in summer than the waters of the lake. This would indicate that the energy inflow may not be of the same sign throughout the year and since the inflow is but slightly larger than the outflow, the net annual energy gain (or loss) from the inflow is very probably *smaller* than the energy outflow which appears to be equivalent to a maximum evaporation of 7.5 cm. We therefore suggest, though *not without reserve*, that the annual amount of evaporation in Table VIII is not seriously in error on account of our inability to compute energy inflow. On the other hand, monthly figures may need correction.

3.3 *A discussion of the results of computations for Lake Hula*

The results in Table VIII indicate an annual evaporation of 168 cm, a result which is in all probability correct within about 15 per cent. The form of the annual variation of evaporation is a simple curve (see Figure 4) with a minimum in December and a maximum in July. The great difference between Lake Hula and Lake Tiberias in this respect is, of course, primarily due to the difference in thermal capacity (= depth) of the two lakes. The relatively large thermal capacity of Lake Tiberias enables it to store comparatively large amounts of heat without raising to high values the temperature of the lake, and particularly that of the lake surface. In spring, the large heat storage in a deep lake requisite for the lake-atmosphere equilibrium, diminishes the amount of heat available for transfer from lake to atmosphere whereby evaporation is brought to a minimum. In autumn, on the other hand, the release of large amounts of heat from storage in the lake, necessary for the lake-atmosphere equilibrium in the the season when the atmosphere cools, supplements the heat supplied by the net radiation surplus at the lake surface and causes the formation of an evaporation maximum in a late month of the year. The spring evaporation minimum and the second minimum in winter make the annual variation of evaporation from Lake Tiberias have the form of a double wave.

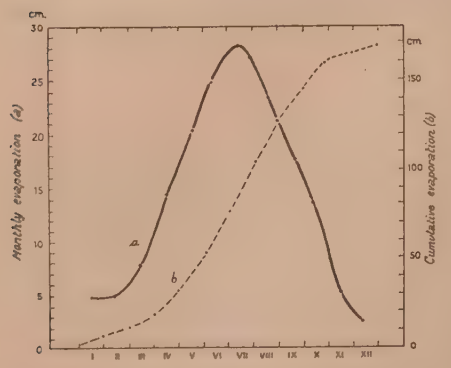

Figure 4

Lake Hula: Curve (a)—monthly amounts of evaporation (computed), left-hand scale; curve (b)—cumulative evaporation (computed), right-hand scale.

The position is different with Lake Hula. The lake and the upper layer of the lake bed in which there is an appreciable annual temperature variation, have a small thermal capacity relative to Lake Tiberias. The combined system of Lake Hula and its bed

TABLE VIII

Energy balance of Lake Hula (computed)

(except for the term representing heat advected by the affluent Jordan + springs + underground seepage)

Term	*Discussed in Section*	*Symbol*	*Equation*	*Jan.*	*Feb.*	*March*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sep.*	*Oct.*	*Nov.*	*Dec.*	*Year*
Insolation (gcal/cm²)	3.21	Q_s		8,900	9,400	13,200	16,900	20,100	23,200	23,400	20,200	17,300	14,500	9,200	8,000	184,300
Insolation reflected from the lake surface	3.21	r_sQ_s	$r_s=0.06$	500	600	800	1,000	1,200	1,500	1,500	1,200	1,000	900	600	500	11,300
Effective back radiation	3.21	Q_b		5,000	4,400	5,000	5,000	5,300	5,600	5,200	5,200	5,400	5,600	5,500	5,800	63,000
Net radiation surplus	3.21	$Q_b=Q_s-r_sQ_s-Q_r$		3,400	4,400	7,400	10,900	13,600	16,100	16,700	13,800	10,900	8,000	3,100	1,700	110,000
Changes in heat storage in the lake	3.22	Q_{Δ}		—300	200	500	600	500	200	100	0	—300	—500	—500	—500	0
Heat conducted into and from the lake bed	3.23	Q_g		400	200	—100	—200	—300	—300	—200	—200	—100	100	300	400	0
Heat advected in by Jordan, springs and seepage	3.24			?	?	?	?	?	?	?	?	?	?	?	?	?
Heat advected out by Jordan	3.24	Q_v		—300	—600	—1,200	—600	—300	—100	—100	—100	—200	—300	—200	—500	—4,500
Total heat available for transfer from the lake surface to the atmosphere		$Q_A=$	$Q_r-Q_{\Delta}+Q_g+Q_v$	3,800	3,800	5,600	9,500	12,500	15,500	16,300	13,500	10,900	8,300	3,700	2,100	105,500
Bowen's ratio	1.1	$R=$	$61.10^{-5}\frac{T_w-T_a}{e_w-e_a}p$	0.27	0.25	0.23	0.11	0.04	0.05	—0.03	—0.02	0.04	0.04	0.16	0.32	
Latent heat of vapourization (gcal/g)		L		590	589	588	586	584	583	583	582	583	584	587	588	
$L(1+R)+10$	1.1			759	744	731	660	617	622	574	582	616	617	694	789	
Evaporation* (cm)	3.3	$E=$	$\frac{Q_r-Q_{\Delta}+Q_g+Q_v}{L(1+R)+10}$	5.0	5.0	7.5	14.5	20.5	25.0	28.5	23.0	17.5	13.0	5.5	2.5	168.0

* Values rounded off.

cannot store up too much heat without raising the temperature of the lake surface to unduly high values. In the constant struggle between lake and atmosphere for radiative and conductive/convective equilibrium, too high a temperature of the lake surface relative to the air, e.g., would create a large temperature gradient above the lake surface with subsequent losses of heat to the atmosphere and an accompanying reduction of the lake-surface (and lake) temperature. Therefore, as the amount of heat available from the net radiation surplus at the lake surface increases from winter to summer, increasing amounts of heat, including latent heat, are lost to the atmosphere: evaporation increases practically monotonously from its winter minimum to a summer maximum. Little heat being available for release from storage in the lake and its bed, evaporation decreases practically monotonously from summer to winter parallel to the decrease of the net radiation surplus. For the above reason, the annual variation of evaporation from Lake Hula is a simple wave.

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OUTLINE ON GROUNDWATER GEOLOGY IN ARID REGIONS*

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SUMMARY: Based on the experience gained in Petroleum Geology a classification of Groundwater Geology—with special emphasis on arid regions—is proposed. Sources, reservoirs, retainers and the various stratigraphic-, petrologic- and structural- groundwater traps are discussed and illustrated.

A. PREMISES

1. Excluded from our research are areas receiving an abundant supply of surface water from gigantic rivers like the Ganges and the Nile, with arteries whose subsoil is continuously replenished by such a water-system. Likewise regions regularly supplied by the snow-melts of the hinterland—as in California—are of minor importance in this presentation. The investigations proposed here are for semi-arid and arid areas where the boring-machine is the final instrument in the search for groundwater.

2. To colonize the deserts and semi-deserts by modern methods of farming—not to speak of industrial enterprises— demands a good supply of groundwater. The yield of a well of a few cubic metres per hour can no longer be regarded as "successful" for a settlement in a dry country; the amount of an average well should be ten to twenty times more.

3. Groundwater chemistry, is not discussed here. The main problem, salinity, is in the majority of cases unsolved.

4. Groundwater is a liquid mineral resource just like petroleum. The science of groundwater includes the following branches: groundwater geology, groundwater engineering, groundwater hydraulics, groundwater chemistry, groundwater economics, etc. Methods used in research and search for groundwaters are the same as those of the oil geologist and oil technician. Adopting this criterion, we have divided the studies preliminary to any groundwater prospecting into four main factors: source material, reservoirs, retainer rocks and structures.

B. SOURCE MATERIALS

Rain is the source material which feeds the groundwater reservoirs of a dry country. A general knowledge of the climate and meteorology of the region to be investigated is of primary importance. The difference between omniseasonal precipitation as in humid Central Europe and seasonal precipitation as in the Southern Mediterranean region is very apparent in the uppermost aquifers. The all-year precipitation of rain-water in humid regions produces a continuous refilling in the upper horizon while in dry regions it is highly dependent on the annual amount of rainfall. The difference

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is felt less in the deeper horizons, whose groundwater is at greater distances, and where precipitation falls on higher topographic ground. In arid zones the deeper horizons are the principal and more constant groundwater reservoirs.

Rainwater which percolates in the rocks has in general a gravitational tendency. An exception is ascending thermal water. Certain phenomena in the artesian basins of Australia (Davis 1950) and North Africa (Drouhin 1951, p.11) are equally explained by upward migration of groundwater from deeper to higher aquifers. The origin of many of the larger springs is possibly due to uplift pressure in open faults or fissures. The surplus of groundwater in coastal plains and deltas and in down-faulted depressions can hardly be explained without considering lateral migration from one tectonic unit to another. Research on the motion of groundwater in sedimentary mountains and depressions will have to include the phenomena of vertical and lateral migration and take account of the experience petroleum science has gained in this respect. However, the major rainwater percolates downwards, i.e. contrary to the major direction of oil migration.

C. RESERVOIRS

A dense limestone in the laboratory-test has a pore space of only 2—4%, and sandstone may attain ten times more. Yet a survey of springs and wells in calcareous rocks reveals yields superior to any of the well-known sandstones of the Albian and Nubian in North Africa, of the Karroo in South Africa and the Dakota in North America. Similarly, a survey by Meinzer shows that of the springs of the first order in the U.S.A., twenty-four are in limestone and three in sandstone. This is due to the fissured, jointed and cavernous nature of calcareous rocks. Since most of the calcareous rocks were subjected to tectonic stress and strain followed by solution of rainwater and percolating groundwater, the calcareous rocks occupy from a practical point of view, the first rank as reservoirs. Too much importance, therefore, has been given to the measurement of granular space volume, and too few experiments have been carried out on the various consolidated rocks in which porosity and permeability are derived from solution, fracturing and fissuring. As long ago as 1915, Du Toit showed that the permeability of the Karroo sandstone is more dependent on jointing than on granular texture. (In the study of physical properties due to structural deformation, the method of petrofabric analysis can play a practical role). Both in reservoir beds (aquifers) and in retainer beds (aquicludes) the influence of thickness is frequently underestimated.

1. *Limestone and dolomite reservoirs*

Limestone and dolomite are consolidated rocks mostly in a folded or faulted state. A lesser degree of density and a higher degree of crystallinity greatly increases the solubility of calcareous rocks and their groundwater conductibility. Dolomitic limestones and reef-limestones are superior in this respect to well-bedded lithographic limestone and pure dolomites. The surface and internal drainage of calcareous terrains is well known; its feature, the karst, is found down to great depths. The great amount of precipitation during the Pleistocene Pluvial period conducted to a fossil karst noted for instance in the countries bordering the Southern Mediterranean. From here the fossil karst reaches far into the arid mainland of North Africa and Arabia where conditions for karst-development no longer exist today. Groundwater circulation in these

arid regions takes place in fossil spaces over large subterranean areas and is responsible for many an artesian and sub-artesian well. With proper retainer beds, thickness and structure, limestone terrains have become the foremost suppliers of groundwater. Greater velocity largely aids the buoyancy of the groundwater. Good examples are:

U.S.A.– The Eocene Ocala limestone in Georgia and Pliocene limestone in Florida produce artesian wells (Stringfield 1936) with little loss in pressure-head which stands in remarkable contrast to the poor results obtained from the unconsolidated though porous younger beds of sand and gravels of these states. It is here, that Swinnerton (in Meinzer 1949) comes to the conclusion that groundwater in limestone terrains shows "greater velocity of flow, greater reservoir capacity, greater availability than in other aquifers". Iowa derives much groundwater from the Niagara dolomites. As mentioned, the best springs in the U.S.A. originate in limestone terrains and obtain yields up to 8000 m^3/hr (Meinzer 1949, p. 424).

South Africa—In Rhodesia where the average yield of (mostly igneous) wells is a few m^3/hr, the great supply for Bwana Mkubwa (Dixey, 1950, p. 506) and Lusaka comes from calcareous formations and Brocken Hill obtains 1000m^3/hr from dolomite at 75 metres depth. In the *Union* all the good cold springs—the best, according to Frommurze, shows 2000 m^3/hr– derive from the dolomite. The chemical properties of the groundwater of the dolomite show the least variability of all formations in the Union (Bond 1946).

North Africa—In Morocco Cambrian limestone in the Anti-Atlas is regarded as the "regulateur fondamental" (Choubert 1951) of the subterranean water-system. In Algeria, in the High plateau and in the Sahara Turonian limestone (Ghardaia, oasis) and Neogene lacustric limestone (Ouagla, Touggourt oases) are good water bearers. The absence of a thick cover is possibly the reason for the reduction in yield (after overpumping) in recent years. The Neogene continental limestone in Tripolitania should, according to Drouhin, possess a strong underflow. In Tunis the importance of the calcareous formation is expressed by all authors (Archambault, Castagny 1950, Tixeront, et Berkaloff 1948). Large amounts of groundwater occur in the Campanian limestone and are connected with blockfault structures. In the Libyan and Egyptian Western Desert the regional plateaux of Eocene limestone lack an adequate cover capable of producing more than insignificant perched horizons. The Miocene limestone of the littoral region is rich in groundwater though too saline to be usable.

Levant– In Israel and former Palestine, the Cenomanian-Turonian limestone and dolomites are the main reservoir providing wells of an average of 200 m^3/hr or one million gallons per diem (Blake and Goldschmidt 1941, Picard 1940). When properly faulted, Eocene limestone becomes productive. All the big springs with an average of 1000 m^3/hr and a maximum of 12,000 m^3/hr derive from these calcareous rocks.

No less impressive are the springs found in and on both sides of the Orontes Valley in Lebanon and Syria attaining in the Tel Aiyun 20,000 m^3/hr. The main reservoir is again the calcaire cenomanienne (Dubertret 1933) with 700 m thickness. Artesian springs and wells are known from Saida on the coast, draining the western flank of the Lebanon. Another not yet exploited rich aquifer is the Jurassic limestone (of 1000 m thickness) emphasized by the large springs of Dan-Banias.

Anatolia—All the major springs in the neighbourhood of Konia (Central Anatolia) originate in Paleo-Mesozoic Limestone which frames this bolson in the south and west.

East Arabia—This area is noted for its wealth of artesian springs (5–6000 m^3/hr at Hofuf oasis) on the Persian Gulf (Heim, 1928). They escape from Tertiary limestone most likely having its intake in the karstic Eocene limestone of the Suman plateau.

India—So poorly developed with good groundwater, has its best well of 80 m^3/hr at Palana (Rajputana) in conglomeratic sandstone contacting the superjacent Eocene limestone.*

Australia—Both in the northern territory and in southern Australia large springs originate in Cambrian limestone. In the Murravian basin the main aquifer is Miocene marine limestone with springs up to 18,000 m^3/hr. (The cover of Pleistocene is, however, too thin for the production of large wells.)

Coral Islands– Both in the Pacific and Atlantic, the islands built of coral-limestone are known for their good supply of groundwater and became of first importance during the Second World War.

2. *Regional sandstone reservoirs*

We exclude from this group the Quaternary-Neogene sandstone of the coastal plains to be found mostly in a half-consolidated state. The term is applied in the main to the well consolidated sandstone found primarily in continental red-bed series which are extended over large areas and are usually connected with regional basin-swell structures. To the sandstone of this type belong: The Cretaceous Dakota sandstone of the U.S.A. Great Plains, the late Paleozoic Puca or areniscas inferiores of the Central Andes, the Permo-Carboniferous Karroo sandstone of South Africa, the Albian intercalaire sandstone of the Sahara, the Paleo-Mesozoic Nubian sandstone of Libya and Arabia, the Jurassic-Cretaceous Artesian series of Eastern Australia. Great thickness and distribution in bowl-shaped basins of regional size made this continental sandstone famous as artesian aquifers in U.S.A. and still more in the Gondwanian continents (Figure 9). With a thick cover in the Sahara and in the Great basin of Australia the aquifers are opened up in fairly great depths and in quantities amounting to 800–1000 m^3/hr. Springs are frequently fossil or subfossil and then indicated by sinter mounds and chria which form the centre of the well-known oases in North Africa.

In contrast to the greater groundwater velocity found in calcareous terrains which in the caverns of the extreme karst may be conducive to turbulent flow, the flow of artesian groundwater in the sandstone of the big basins is thought to be slower and more continuous; it has been compared by Meinzer with the surface movement on a nearly stagnant lake.

The Karroo sandstone has, apparently, often been divided into compartments by faults and dykes. Opinions differ as to a true water table (Frommurze 1931) in this formation: the yield is also a comparatively low (70m^3/hr in Kenya is above the normal). Genuine artesian wells have, however, been developed recently in the Ecca sandstone of Southwest Africa (Frommurze 1931).

* Information kindly supplied by Dr. R. D. Dhir.

3. *Unconsolidated and semi-consolidated sediments*

To this group we attach the prevalent Quaternary-Tertiary clastic sediments which fill up the larger and smaller inland plains or the little deformed coastal plains (Figures 2, 3, 4). They consist of gravel, silt, sand and soft sandstone, are highly permeable and become aquifers through intercalation or lensing with less pervious sediments. In the regional high plains of the U.S.A. or in the Pampas of Argentina, structural deformation and buried hills-configuration may result in artesian conditions. But as a whole these "alluvial" and coastal fillings produce the stratigraphic trap of groundwater.

Apart from the coastal plain reservoirs the alluvial and high plain deposits have a medium or low groundwater yield. It is true, that in the U.S.A. the wells of the high plains or of some larger bolsons "rank among the first in quantity of water" (Meinzer 1923), but there the yield of 20 m^3/hr of a single well is regarded as a large amount and the average of 5—10 m^3/hr is regarded as a good supply. In most cases a few cubic metres per hour is the average yield in semiarid—arid regions even at greater depths. The so called "Karez" system, an ancient system of subterranean galleries of shafts, has favoured the regions of such unconsolidated material and for instance in Cyprus (Raeburn 1945) has ten times increased the normal yield of a single well.

In many an intermountain trough, difficulties are encountered in correlating the groundwater level of the various wells. The yield of wells in valley fills in dry areas depends greatly on the annual rainfall and differs fundamentally from the constant replenishment a humid valley receives from the atmosphere. In the gravel plains and alluvial fills of the desert and half-desert, drillings very often remained without practical results. They improved in regions where volcanic dykes cut the "alluvial" deposits and had a barrage-effect on the underground flow. In attempts to find artesian water a tout prix, many costly but fruitless drillings were carried out in the central part of intermountain depressions and valleys, neglecting in the same area the better conditions which exist for groundwater discovery in the adjacent faulted or flexured slope of the mountain border.

The sedimentary fillings of the coastal plains were much influenced by the frequent up- and down movement of the Pleistocene sea level. Marine sediments alternate with continental sediments; nonclastic thick retainer beds form base and cover. This leads to a sandwich-type of strata with repeated aquifers and aquicludes.* Large amounts of groundwater were discovered in this situation in British Guiana and East Africa (Dixey 1952) but especially in the Southern Mediterranean coastal regions. In the Philistaean Plain of Israel they deliver an average of 100 m^3/hr per well. Too frequent alternation and lesser thickness of aquicludes and aquifers are possibly the reasons for the smaller yield recorded from Pleistocene borings in Cyprus. No cover and small extension in height restrict the groundwater of coastal dunes to inferior quantities and to domestic use.

4. *Igneous and metamorphic rock-reservoirs*

Only 30% of outcropping rocks on the land surface are igneous and metamorphic. Apart from this, the character of these crystalline rocks often opposes—as in the case of petroleum—a proper circulation of the liquid in deeper ground.

* Akin to this type—although mainly of Cretaceous age—are the groundwater bearing strata of Long Island in the coastal plain of New York (Thompson, Wells and Blank 1937).

a. Plutonic and metamorphic terrains

Granite and other plutonics rarely supply more than 1—4 m^3/hr groundwater and consequently give rise to only small springs. Examples are many and most frequently described from grazing—and flock-farming regions of East and South Africa and from Sudan. Here as in India the shallow-dug well ("Hafir" of the Sudan) is the predominant supplier. Jointing and weathering are the prerequisites for both permeability and retaining of groundwater. No general groundwater table exists under these conditions. Somewhat better hydrologic relations are found in metamorphic schists and gneisses when sandwiched between thick marble or quartzite. The instances (20 m^3/hr) are, however, so seldom that we find them especially emphasized in the literature on Africa (Dixey 1952, Frommurze 1937). Plutonics and metamorphics are thus the poorest reservoirs of groundwater to be searched for in arid and semiarid countries.

b. Volcanic terrains (sheet lavas and dykes)

Sheet lavas intercalated by sediments or volcanic tuffs may operate in both ways: as retainer when of a compact or as reservoir when of a vesicular structure. Jointing naturally increases the permeability and this is still more noted in fissured fault zones. There groundwater may be found in quantities but next to it the non-faulted part may be completely dry. Dykes crossing older basalts divide them into separate hydrologic blocks. Large springs resembling Karst springs are known to escape from porous pahoehoe basalts. Stearns and MacDonald (1946), have presented an excellent discussion of volcanic terrains (also Stearns in Meinzer 1948), but their examples refer to humid regions. The regional Plateau-lavas and volcanic-trap landscape of dry regions (e.g. Dekkan) are little investigated in this respect. The nature and thickness—over 1000 metres—present difficulties concerning geophysical research and drilling costs. The supply of groundwater by borings in volcanic terrains such as basalts in desert regions is still a matter of luck. The effect of dykes on alluvial fillings or other sediments mentioned before, was best studied in South Africa since "in more than half of the Union the concentrations of groundwater are largely controlled by intrusive dykes" (Frommurze 1937). Favourable conditions exist for the barrier action of dykes: "When the dyke is wide enough and more resistant to weathering than the country rock, and when the catchment area is free from other dykes and of a size sufficient for accumulation of groundwater" (Fommurze 1952). Fairly good results (25 m^3/hr) were also obtained during the last war in the Egyptian Eastern Desert (Shotton 1946).

D. RETAINER ROCKS

In analogy with oil research, cover and basal retainers fundamentally influence the amount of groundwater and the pressure of aquifers.

1. *Igneous and metamorphics*

Lava sheets become of importance as retainers—covering alluvial fills (Australia) and other sediments. Plutonics and metamorphic rocks increase their retaining properties by weathering and covering the surface with residual soil.

2. *Clay, marls and shales*

Sand added to these retainer rocks produces shaly sandstone or sandy shales which somewhat change the retaining capacity. But even flysch and greywacke never become proper reservoirs. Australia gives good examples of cover and basal retainers the requisiteness of abundant artesian groundwater. When the cover is missing as in the Miocene karstic limestone of the Eucla basin, groundwater supply is much reduced. According to David (1950, p. 515) we observe: "a departure from artesian conditions where there is complete absence of a confining impervious layer." The importance of thickness is further demonstrated by the big section of Cretaceous shales which cover the Jurassic-Cretaceous aquiferous sandstone in the classic Great Australian basin. The roof of Cenomanian marls which protects the Albian sandstone in the Algerian Sahara (Golea) is a further characteristic example. Fox illustrates another artesian phenomenon caused by thick clay beds which cap the alluvial fill of the Quetta Valley of India.

3. *Chalk*

The siliceous chalk of the Cretaceous of Northern Europe is regarded by many as permeable and water bearing. The Cretaceous-Lower Tertiary chalk so common in North Africa and the Middle East is, however, an excellent retainer. The Paleocene—Senonian chalk and marly chalk of the Levante enables the Turonian—Cenomanian limestone and dolomites to become the main aquifer and to produce perfect subartesian conditions.

The Dakota sandstone of the U.S.A. with an average thickness of only 50—100 metres owes its artesian groundwater property no less to 1000 metres of superincumbent chalk and shales.

Ideal conditions for the exploration of the groundwater exist, therefore, in regions where, apart from the respective structure, retainer and reservoirs reveal a proper thickness; a situation which speaks in most instances for deep-well drilling.

E. GROUNDWATER TRAPS

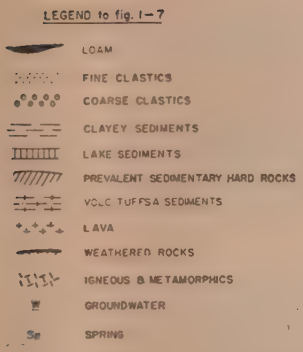
Reservoirs and retainers are genetically interwoven with stratigraphy, structure and morphology. Following the nomenclature of oil science a first attempt is made to arrive at a genetic classification of groundwater traps.

1. *Stratigraphic trap*

Although sediments rarely remain uninfluenced by some pre- or post-depositional movements, the term stratigraphic trap is assigned to reservoirs in which groundwater accumulation and migration is primarily conditioned by the stratigraphic type or form of deposition and less by structural deformation.

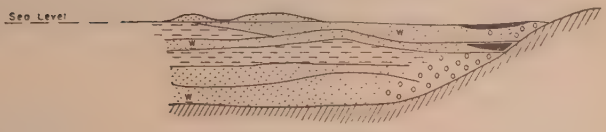
a. Littoral type (Figure 1)

Material: unconsolidated sand, gravel, silt. Stratification: irregular, lenticular, interfingering, crossbedding. Landscape: coastal dunes, dry river debouchure. Groundwater yield: small. Groundwater pressure: low or none. Depth of wells: shallow because of salinity. Age: Recent-Pleistocene. Guide example: Sinai Coast.



LITTORAL

Figure 1



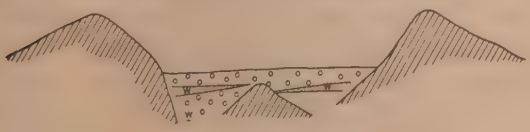
COASTAL PLAIN

Figure 2

b. Coastal plain type (Figure 2)

Material: Semi-unconsolidated sandstone, sand; alluvial gravel and loam near mountcains. Stratification: parallel-bedded and sandwiched (alternating clastics and nonclastics), crossbedded and interfingering, lensing less frequent. Landscape: plain with ridges of hardened dunes cut by coastal consequents. Groundwater yield: good to very good. Groundwater table: continuous with slight gradient (1°— ½°). Subartesian pressure. Depth of wells: 50—100 metres. Salinity increases through overpumping. Age: Pleistocene-Pliocene. Guide example: Israel, Morocco.

c. Intermountain trough type (Figure 3)

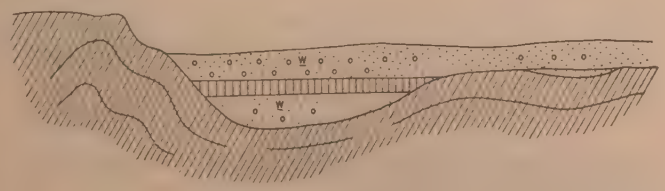


INTERMOUNTAIN TROUGH

Figure 3

Material: Continental gravel, clay, loam, lake deposits, occasionally volcanics. Stratification: well bedded or interfingering and lenticular. Landscape: Bolson-depressions covered by red earth, or ancient lake sediments or fan clastics—also by adobe. Wells: in alluvial fill rarely sucessful and depending on rainfall. Groundwater hydraulics restricted to trough. Subartesian in deeper aquifers. Age: Cenozoic. Guide examples: basin-ranges and bolsons of America.

d. Pampas-high plain type (Figure 4)



PAMPAS-HIGH PLAIN

Figure 4

Material: Similar to previous type but accumulated and distributed on a regional scale. Landscape: Steppe plain, windmill country, loess and dust prairies. Yield: medium to small. Groundwater mostly subartesian; but in depths occasionally subdivided in basins and then artesian. Age of the less consolidated material: Tertiary-Quaternary.

Examples: Pampa (high plains) of Argentina and Great Plains of the U.S.A. Ganges— and Mesopotamian—depressions are related types. (See also discussion on regional basin type).

2. "*Petrologic*" *trap*

For lack of a proper term we have preserved the popular though less accurate name "petrologic" adopted in oil exploration for traps connected with igneous and metamorphic rocks.

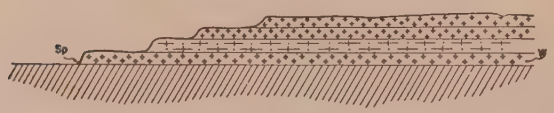
a. Crystalline massif type (Figure 5)

CRYSTALLINE MASSIF
Figure 5

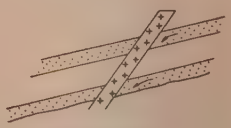
Material: Prevalent plutonics and metamorphics. Groundwater in jointed or in decomposed rocks or in pockets of ancient thalwegs with alluvial fill or lying unconformably on ancient eroded land surfaces. Yield: very little. Morphology: crystalline torso mountains. Well-digging country. Guide example: East Africa.

b. Lava plateau type (Figure 6)

Material: Lava sheets and sills with sedimentary intercalations or interbedded volcanic tuffs. Yield: abundant in humid regions but very variable in arid regions. In semi-arid high mountains springs arise at the impervious sedimentary basement and this is also the best location for well drillings. According to Stearns the gradient of the water table is dependent on the slope of this basement. Examples: Yemen, Hauran. Remark: in faulted zones good water bearer. Intercalated sediments may produce artesian water. Examples: Columbia plateau, Kenya.



LAVA PLATEAU
Figure 6



IGNEOUS DYKE
Figure 7

c. Igneous dyke type (Figure 7)

Known for its barrier-effect described on page 363. Dykes cut sediments and igneous rocks and localize the water-table into compartments. Yield: modest. Guide examples: Union of South Africa.

3. *Structural trap*

Structurally groundwater is grouped in traps connected with folding and bending, and with faulting.

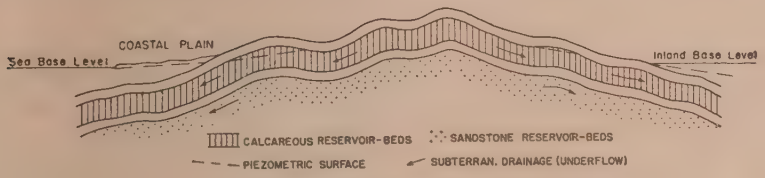
Traps due to bending

Strongly compressed fold mountains of the Alpine style are unfavourable for groundwater prospecting. The sedimentary rocks are often metamorphous or highly conso-

lidated; fissures and joints are—like the major thrust faults—strongly mineralized and "healed". Uplifted to heights in which any hydrostatic head would practically be too deep for exploitation. Water for these little populated regions is supplied directly from snow, ice, rain, dew and mist and collected in perennial rivers. Other mountains with complicated structure like the North African Riff and many a mountain of diapir structure are likewise improper groundwater traps. Groundwater exploration in bended structure becomes thus restricted to the belts of simple, autochthonous, normal folding.

a. Simple fold mountain type (Figure 8)

Search for groundwater in folded mountains is usually restricted to plains and depressions in which better possibilities for settlements and agricultural development exist. More explored in this respect are the mountains of the Levant, and of the



SIMPLE FOLD MOUNTAINS

Figure 8

Sahara and Middle-High Atlas, which apart from much faulting, possess a related tectonic style. The experience gained from these Southern Mediterranean countries has shown that in the presence of good reservoir and retainer beds plenty of groundwater can be disclosed in the main aquifers. The groundwater is generally under pressure and the pressure head is regulated by the base level of the sea or of an inland depression. The water table is continous unless depressed in the vicinity of a fault (to be discussed later). Perched horizons of lower yield and depending on annual precipitation produce a still higher hydrostatic niveau. Most simple folded countries are of synclinorial–anticlinorial type which in the case of a synclinorium may supply artesian groundwater (e.g. Lebanon coast). The high plateau of Algeria between Tellian and Saharian Atlas can be regarded as a synclinorium of a regional size, the shotts of which are artesian seepages (springs with 500 m^3/hr and borings with 1200 m^3/hr). This phenomenon introduces us to the following section: regional artesian basins.

b. Regional basin type (Figure 9)

The term regional basin is here used for the huge sedimentary bowls which—in combination with their adjoining giant swells or upwarps—produce on the continental shields a distinct basin-swell configuration. The basins have become classical regions of artesian groundwater research in Africa and in Australia. In a certain sense the afore mentioned Pampa-Great Plains could be added here though they have no basinal closure and are more characterized by the aquifer of their enormous Quaternary

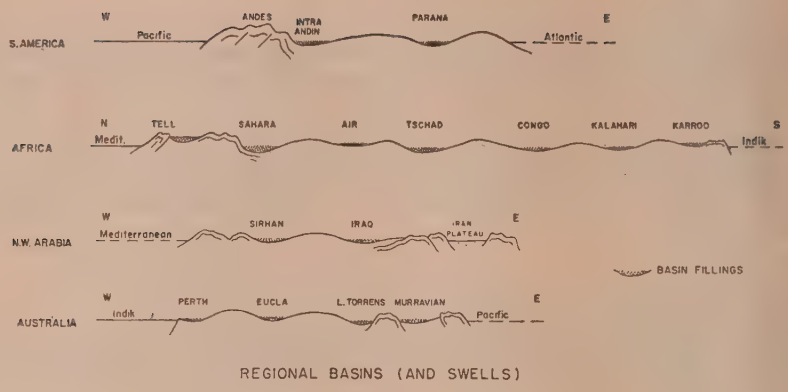


Figure 9

alluvial fillings. The above figures illustrate the general structural basin-swell outline of the Gondwanian continents (Picard 1939). In India a good deal of this structure is covered by Dekkan trap lavas. The groundwater reservoirs of these regional basins consist of consolidated prevalent marine calcareous rocks or of prevalent continental sandstone, the witnesses of former major epi-continental transgressions or continental regressions. In North Africa and Arabia fossil karst (dayas) has greatly influenced the development of an extensive subterranean water-net. The stratification of the reservoir beds is parallel- and well-bedded and is sandwiched between thick retainer beds of marls, shales and calcareous chalks. The landscape is of plateau morphology but passes towards the swells (principally crystalline massifs) into giant cuestas known in the native language: krebs, tassili, batn. Here the groundwater is subartesian and springs form oases on the cliff border of the cuestas. Such cuesta-oases are Golea in the Sahara, Kharga-Dakhla in the Egyptian-Libyan Desert, Hofuf in Arabia. In the smaller upwarps, still covered by sediments, erosion has carved out in the strata funnel-shaped valleys at the bottom and flanks of which springs now appear. This "anticlinal" type of springs is typically represented in the oasis of Bahariya in the Egyptian Western Desert. Other quite common artesian seepages are the partly subfossil travertine of the afore-mentioned mounds and chrias. Distribution and mechanism of artesian groundwater is well described from the U.S.A. by Meinzer (1949), from North Africa by Savornin (1930) and by Ball (1927), from Australia by David (1950). The depth of wells varies from a hundred to several hundred meters average; the yield varies between 100 and 300 m^3/hr, and greatly depends on the thickness of the cover-beds, (there is always the danger of overpumping especially in the higher aquifers). Another characteristic of the artesian groundwater of these arid regions is the decrease in salinity with depth, a phenomenon which stands in contrast to the groundwater of coastal plains and speaks against the assumption of connate marine water influencing the artesian groundwater.

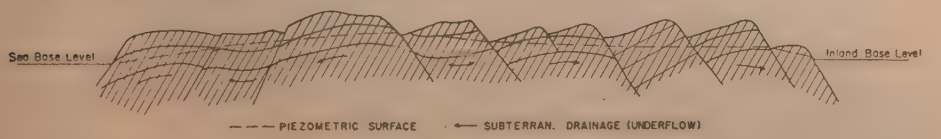
Traps due to faulting

The effect of faults on groundwater bearing and groundwater circulation is only felt (1) in those open tensional faults of Quaternary to Recent age—where no healing has

taken place, and (2) in hard rocks. Thrust-faults of high and low angle have a disturbing influence on aquifers. Faults in the unconsolidated gravels, loams, sands of the alluvial fill and of the coastal plain have not proved to be of great help in detecting groundwater. As a whole, the fault—even of a tensional nature—has more a sealing than an opening effect in unconsolidated sediments. Faults in plutonics and metamorphics are of little importance because of the impermeable nature of the country rock. Only in the immediate neighbourhood of the fault a slight increase of the poor yield—which characterize these rocks is noted. And this again can only be expected in rather recent faults in which no mineralization of the fault zone has taken place. Faults in lava terrains should have a positive effect on the groundwater bearing properties, in particular when intercalated or interbedded by non-volcanics or volcanic tufa. The conditions would then resemble the fault-blocks of sedimentary mountains. However, the literature studied by us has not supplied us with sufficient information. From our experience in the tilted block mountains of Galilee in Israel, it would appear that faults in lava terrains had a more closing effect and groundwater is found a short distance away from the fault in the down-throw block. This resembles in a way the behaviour of dykes pointed out very recently by Frommurze (1952). Faults in consolidated sediments have proved a first class structural trap in many ways superior to the regional basin type. Here again calcareous rocks and sandstone are the best reservoirs; limestone and dolomite have top priority. These hard rocks segmented by faults thus produce a special structural type—the fault-block type. The importance of fault-blocks in groundwater prospecting has been underestimated in the same way that oil prospecting in earlier years underestimated closures due to faulting.

c. Fault-block mountains type (Figure 10)

The appearance of groundwater seepages, in other words springs with abundant water along the fault zone, has been known for a long time. The good examples which still remain classic were brought from the type country of block-structures, from the Basin-Ranges. Fault-springs in the Edward Limestone (Livingstone, Sayre and White 1936) were again emphasized in a recent instructive article by Swinnerton (1949). Yet nearly all borings in search for groundwater were carried out in the basin-fillings and revealed yields absolutely inferior to the amounts the fault-originated springs had given. A similar experience was made in another country of typical block-structure in northern Israel or Galilee where up to the last fifteen years borings were restricted to the depressions, although the great springs on the borders and on fault escarpments of the calcareous mountains had spoken in favour of drilling in the fault-zones (Picard 1941) and in hard rocks. As mentioned, groundwater flows here in the Upper Cretaceous-Jurassic limestone and dolomites of great thickness, and finds its outlet in enorm-



FAULT-BLOCK MOUNTAINS

Figure 10

ous and often gigantic springs. In Israel, the Cenomanian limestone and dolomite has become the principal productive reservoir with an average yield of 200 m^3/hr, and in several cases supplies 500 m^3/hr per well with insignificant drawdown.

The groundwater in Israel is, apart from the region of the divide, nearly always under subartesian pressure. The pressure head has a gradient of 1°—2° from the region of the divide to the Mediterranean. The gradient towards the Jordan Rift Valley is not yet known, but near the abrupt fault escarpment of the Dead Sea, there is a sudden drop of the water table of 200 metres (80°—90°). Such a depressing effect on the hydrostatic level near a fault zone was also noted, though in a much lesser degree, on the fault-scarps of the tilted blocks in Galilee. Thus the above mentioned gradient of 1°– 2° in a block-faulted country is not a straight-line but, due to the dragging down of the water table at the fault scarp of a more sinuous character. In the higher and perched horizons (e.g. Eocene limestone), this phenomenon is less clearly observable.

Drilling in the Galilean district was best advised on the fault scarp of the elevated block. Many fault-scarplets on the major escarpments demonstrate a very young date and might be considered as larger earthquake fissures. They have become perfect locations for drillings provided that the pressure head is not too low and pumping not too expensive.

Tunisia is a country with a similar experience and related structure. There the Campanian limestone, for instance, has played the same role as reservoir rock and there block-faulting again dominates over the preceding "foreland" folding (Castany 1950, Archambault 1947).

F. CONCLUSIONS

1. The best reservoir rocks are hard rocks: limestone and dolomite followed by sandstone.
2. Good retainer beds, to include the (slightly marly) chalk of the Mediterranean area, are more dependent on thickness than on the amount of clay content.
3. The best groundwater traps are structural basins of regional magnitude and block-faulted sedimentary mountains.
4. The coastal plain types are the best stratigraphic traps.
5. Too much importance has been given to alluvial fill as groundwater reservoirs.
6. Plutonics and metamorphics are inferior groundwater reservoirs.
7. Lava-sheets and dykes reveal a great variability as aquifers.

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ON THE IDENTITY OF *HAEMAPHYSALIS ERINACEI*, AND *H. TAURICA**

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SUMMARY: *H.erinacei* Pavesi 1884, is re-established as a valid species and redescribed. *H. numidiana* Nn (1905) is sunk into synonymy with *H. erinacei* because of the priority of Pavesi's name. The description of the female of *H. erinacei* by Pavesi was based on nymphs of *H. excavatum* K. The type of the female of *H. erinacei* should therefore be that of *H. numidiana* Nn.

H. numidiana turanica Pos.-Str. is a synonym of *H. erinacei* Pav., while *H. numidiana taurica* Pos.-Str. is a synonym of *H. taurica* which is a valid species.

H. erinacei F.M. is sunk temporarily into synonymy with *H. taurica*. The female of *H. taurica* is described.

Pavesi (1884) described one male and several specimens which he thought to be the corresponding females, taken from *Erinaceus algirus* from Gebel Resas in Tunisia as a new species which he named *H. erinacei*. Neumann (1911) does not seem to have seen Pavesi's material and considered it only on the basis of its description; he listed the species as a doubtful one, and expressed the view that it might be identical with *H. concinna* Koch, while Pavesi in his original publication had considered it only allied to this species.

In 1905 Neumann created the name *H. numidiana* for a *Haemaphysalis* found in Algeria on a hedgehog. Nuttall et al. (1915), in their monograph on *Haemaphysalis*, regarded *H. numidiana* as a "somewhat doubtful species" but preferred to retain it temporarily. According to their description it is "very large compared with the average *H. leachi*". But the comparison of Nuttall's drawings of *H. leachi* and *H. numidiana* with due regard to the scales shows only a very slight difference in size: the length of the scutums of *H. leachi* being 2.8 mm and that of *H. numidiana* 2.9 mm.

Nuttall considered *H. erinacei* Pav. as "merely a nominal species, the description being insufficient" but he did not see Pavesi's specimens. In the course of time Pavesi's species was completely forgotten and received no further mention in the literature while Neumann's *H. numidiana* has been accepted.

Pospelova Strom in Russia, in her key to the Russian species of *Haemaphysalis* (in Pomeranzev's paper, 1946), divided *H. numidiana* into 2 subspecies, *H. numidiana turanica* and *H. numidiana taurica*, relying on differences in length of the hairs on the coxae, and the length of the pulvillum in relation to that of the claws. *H. numidiana turanica* has short hairs on the coxae, and the pulvillum is less than half the length of the claws, whereas *H. numidiana taurica* has long hairs on the coxae and the length of the pulvillum is about 2/3 of the length of the claws.

In 1951, the present author described a new species, which was named *H. erinacei*, without being aware of Pavesi's *H. erinacei* or Pospelova-Strom's *H. numidiana taurica* and *H. numidiana turanica*. As *H. erinacei* is preoccupied, *H. erinacei* Feldman-Muhsam must be renamed. Pomeranzev's paper suggests the possibility that *H. erinacei*

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Fel.-Muh. might be identical with *H. numidiana taurica* Pos.-Str. So far we have not been able to trace the original description of this variety, and for the present *H. erinacei* Fel.-Muh. will be considered as a synonym of *H. taurica* although Pospelova-Strom gives no drawings and no description beyond reference to coxal hairs, pulvillum and claws in a synoptic table.

As already mentioned Pospelova-Strom points out (in Pomeranzev 1946) that *H. numidiana turanica* has short hairs on the coxae, whereas *H. numidiana taurica* has long hairs on the coxae. In specimens which I had called *H. erinacei*, the hairs on the coxae are not only longer than in *H. erinacei* Pav., but also much more numerous as our drawings show very clearly (Figures 2 and 5). On the other hand, there is no evidence of any significant correlation between the relative length of pulvillum and claws in material examined by the author.

Through the courtesy of Dr. Delfa Guiglia of the Museum of Genoa, and Prof. Brizard from the Ecole Nationale Veterinaire of Toulouse we have been able to examine the type specimens of Pavesi and Neumann. The only difference which we have found between Pavesi's specimen and that of Neumann is in the colour. Neumann's specimen is pale yellow, whereas Pavesi's is light brown. We therefore think it justified to consider them to be identical. As Pavesi's name has priority to that of Neumann, the name *H. numidiana* should fall and the species be called *H. erinacei* Pavesi. Pavesi's description of his *H. erinacei* is very vague and insufficient for diagnostic purposes, and we therefore add a redescription of his type.

From Pospelova-Strom's key for the genus *Haemaphysalis* it seems that *H. numidiana turanica* is the same as *H. numidiana* Nn. According to the laws of nomenclature she should have called it *H. numidiana numidiana*. In consequence *H. numidiana turanica* should be called *H. erinacei* Pav. But since *H. numidiana taurica* is a valid species, it should be called *H. erinacei taurica* if considered as a subspecies, or otherwise *H. taurica*.

H. ERINACEI PAVESI

1 male found by Marquis Doria on *Erinaceus algirus* at Gebel Resas, Tunisia, in 1881.

Male. The length of the scutum from the middle of the line joining the scapulae to the posterior end of the scutum is ca. 2.8 mm. The scutum is uniformly covered with large and scattered punctations. The lateral grooves include two festoons. The colour of the scutum and the legs is light brown (Figure 1). The basis capituli is wider anteriorly (Figure 2). The cornua are unfortunately broken; (but the male type of Neumann has moderately long cornua). The second article of the palp is very salient laterally and has no retrograde projections such as found in *H. leachi*. There is a ventral retrograde process on article 3 of the palp (Figure 2).

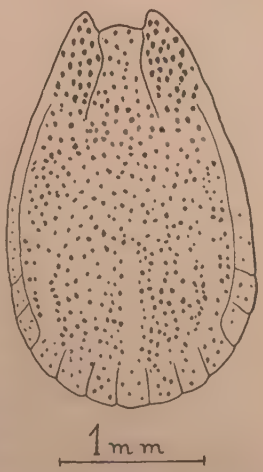

Figure 1
Haemaphysalis erinacei Pavesi.
Male type. Scutum.

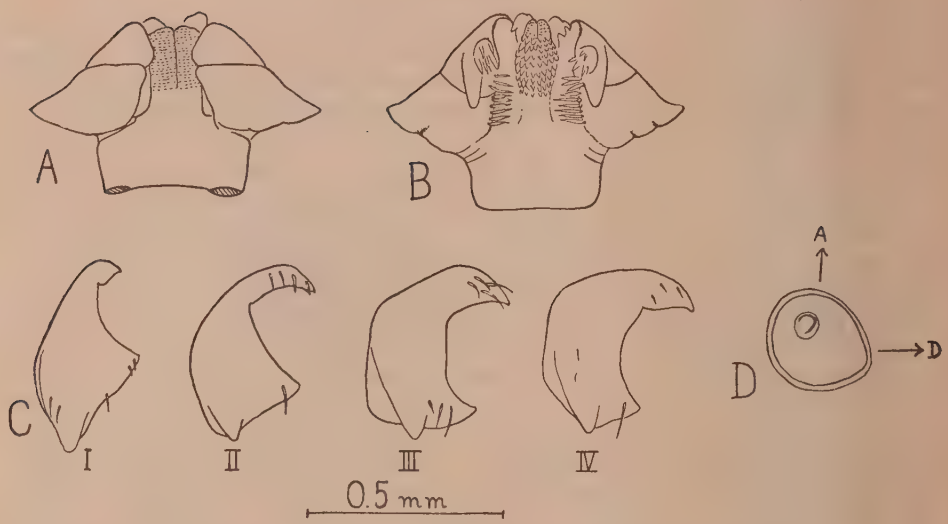

Figure 2
H. erinacei Pavesi. Male type. A—Capitulum, dorsum. B—Capitulum, venter. C—Coxae. D—Spiracular plate.

The dentition of the hypostome is 4/4, 8 teeth per file. The corona of the hypostome is high and clavate. All coxae bear small spurs, short and scanty hairs (Figure 2 C).

Female. The ticks which Pavesi described as females of *H. erinacei* are actually nymphs of *Hyalomma excavatum* Koch.

The type specimen for the female of *H. erinacei* should therefore be the type of Neumann's *H. numidiana* (Neumann's collection No. 999). This female together with 2 males were taken from an *Erinaceus* sp. at Tebessa (Algeria). (There is only one male now in Neumann's collection in Toulouse; 1 male, co-type [N. 2890] is in the British Museum).

Neumann's description of the female is incomplete and we therefore add the following brief description. The scutum is longer than wide, c. 1.2 × 0.9 mm, covered with large punctations (Figure 3 E). Its colour is light brown. The form of the capitulum is very similar to that of the male. The basis capituli is almost rectangular, somewhat wider anteriorly. The area porosae dorsalis are elliptical with their long axis converging anteriorly. The cornua are small, but well defined (Figure 3 A). The second article of the palp is very salient laterally and has no retrograde projections. The 3rd article of the palp has a ventrale retrograde process. The dentition of the hypostome is 4/4, 9 teeth per file; the corona of the hypostome is broken. All coxae have small spurs on their medial aspect and are covered with few hairs only (Figure 3 C). The genital aperture has two widely open flaps, the underlying tube is short (Figure 3 D). It is quite distinct from that of *H. leachi*.

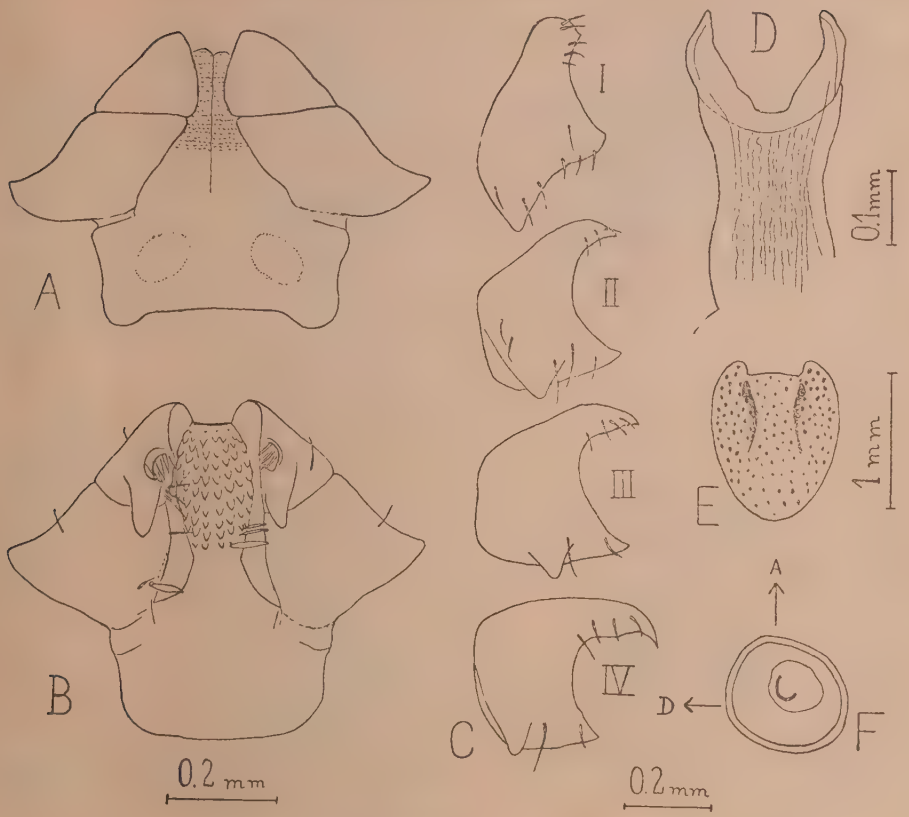

Figure 3

H. erinacei Pavesi: Female type (The type of Neumann's *H. numidiana* N. 999). A—Capitulum, dorsum. B—Capitulum, venter. C—Coxae. D—Genital aperture. E—Scutum. F—Spiracular plate.

HAEMAPHYSALIS TAURICA Pos.-str.

Male. The male of this species has been described in a previous paper. We now add drawings of the coxae which show the long and numerous hairs in contrast to the coxae of *H. erinacei* Pav. (Figure 4).

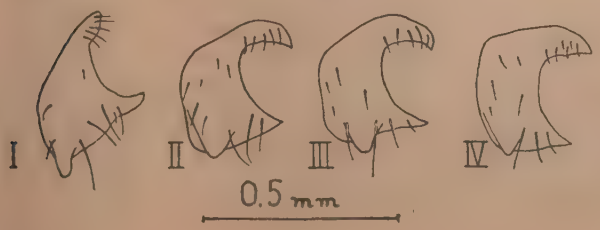

Figure 4

H. taurica Pos.-Str.: Male. Coxae.

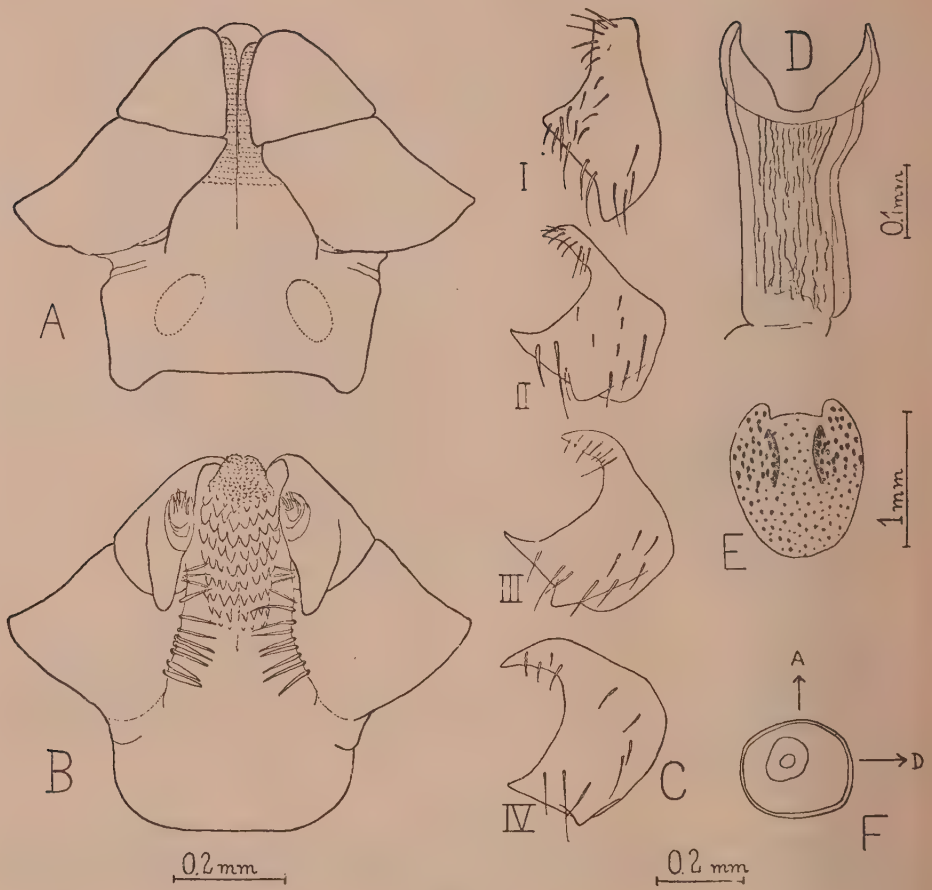

Figure 5

H. taurica Pos.-Str.: Female.
A—Capitulum, dorsum. B—Capitulum, venter. C—Coxae. D—Genital aperture. E—Scutum. F—Spiracular plate.

Female. The scutum is longer than wide; its maximum length, from the middle of the line joining the tips of the scapulae to its posterior end, is 1.2 mm. Its maximum width is 1 mm. Its colour is light brown, and it is uniformly covered with conspicuous punctations. The basis capituli is wider anteriorly, the cornua well developed. Area porosa dorsalis elliptical converging anteriorly. The form of the capitulum is the same as in *H. erinacei* Pav. The dentition of the hypotome is 4/4, 8 teeth per file (Figure 5). All coxae bear small spurs. There are many hairs on the coxae, some of them are long (Figure 5 C).

The genital aperture is very similar to that of *H. erinacei* Pav. (Figure 5 D).

DISCUSSION

H. numidiana Nn. has rarely been mentioned in the literature after Neumann's first description. It was mentioned by Olenev from Russia in 1928, and by Basukhin in 1933 as being present at the lower Volga region and Western Kazakstan.

We were able to examine in the Museum of Genoa 2 ticks taken from a wolf at Budrum, Asia Minor (8.11.1919) which belong to *H. taurica*. These males were determined by Nuttall as *H. leachi*, Asiatic form. Another similar male from our collection was determined by Warburton as *H. leachi*, non typical form. On the other hand, Schulze determined such ticks as *H. numidiana*. G. M. Kohls from the Rocky Mountain Laboratory kindly sent us 2 females from Schulze's collection, determined by Schulze as *H. numidiana* collected in "Höhle am Pantokrator", Greece (3.4.1929). These 2 females have pilose coxae and should therefore be diagnosed as *H. taurica*. H. Hoogstraal from the U.S. Naval Research Unit kindly sent us 1 male of *H. numidiana* Nn (= *H. erinacei* Pav.) taken from *Hemiechinus libycus* in Egypt, Western Desert.

There is no doubt that the two allied species *H. erinacei* Pav. and *H. taurica* Pos.-Str. are more widespread than it is mentioned in the literature. It seems that some specimens belonging to *H. erinacei* Pav. or *H. taurica* Pos.-Str. were determined by Nuttall as *H. leachi* and also listed in the geographical distribution of the latter species in his monograph on *Haemaphysalis*.

There is no doubt that *H. erinacei* Pav. (= *H. numidiana* Nn) is a valid species, and that Nuttall was mistaken when he thought it doubtful. *H. erinacei* and *H. taurica* are closely related species. The main difference found between them is in the length and number of the hair on the coxae. As the chaetotaxy of the appendages in the Ixodidae is remarkably constant we consider the above difference sufficient for the separation of the species.

LIST OF SYNONYMS

H. erinacei Pav. syn. *H. numidiana* Neumann, 1905.
H. numidiana turanica Pospelova-Strom
H. leachi (Audouin, 1927) Neumann, 1897, sensu Nuttall, 1915 p.p.

H. taurica (Pos.-Str.) syn. *H. numidiana taurica* Pospelova-Strom
H. erinacei Feldman-Muhsam, 1951 (temporarily)
H. leachi (Audouin, 1827) Neumann, 1897, Sensu Nuttall, 1915 p.p.

ACKNOWLEDGEMENT

We wish to thank Prof. Brizard from the Ecole Nationale Veterinaire de Toulouse, Dr. Delfa Guiglia of the Museum of Genoa, for their kind permission to study the type specimens, as well as Dr. G. M. Kohls from the Rocky Mountain Laboratory, and Dr. H. Hoogstraal from the U.S. Naval Research Unit for the gift and loan of specimens.

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A COMPARATIVE STUDY OF THE PHYTOPLANKTON OF SEVERAL FISH PONDS IN RELATION TO SOME OF THE ESSENTIAL CHEMICAL CONSTITUENTS OF THE WATER*

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SUMMARY: A study of three types of fish-ponds in the Beisan Valley was carried out with a view to examining the relationship between some essential chemical constituents dissolved in the water (nitrogen, phosphorus and silicon compounds) and the development of phytoplankton.

An inverse correlation was observed between the diatom abundance and the nitrate nitrogen concentration of the water. The development of diatoms, however, did not seem to be directly influenced by ammonia nitrogen. The growth of several species of green algae seemed to be stimulated by ammonia nitrogen and nitrate nitrogen. Inorganic nitrogen did not seem to affect the development of Cyanophyceae, Eugleninae and Cryptomonadinae.

Minute quantities of phosphates in the water seemed to be sufficient for an adequate development of diatoms while higher concentrations seemed to increase even further their development. A direct correlation has been observed between the phosphate concentration of the water and the development of green algae. Phosphates, however, did not affect the development of Cyanophyceae, Eugleninae and Cryptomonadinae.

During the winter and summer maxima of the diatoms there is a distinct drop, often nearing exhaustion point, in the silicon content of the water.

In the course of the phytoplankton examination, over 140 species and varieties of planktonic algae have been recorded and identified in all the ponds considered in this investigation. While blue-green algal blooms are common to all these ponds, a distinct predominance of diatoms was noticed in those of high salinity, and of green algae in those of low salinity. In those ponds where the blue-green algae bloom all year round, the Hormogonales are more common during the winter, while the Chroococcales are dominant in the summer. While *Microcystis flos aquae* was found to be common in all the ponds, *Microcystis aeruginosa* was encountered only in ponds of low salinity. The occurrence of *Euglena granulata* and *Cryptomonas erosa* in large numbers at the end of the summer may be due to the fertilization of the ponds with organic manure and the decay of the blue-green algal blooms at this season.

Organic manure was found to be an effective but slow source of supply of nutrients for phytoplankton. The effect of chemical fertilizers is more immediate but does not last as long.

INTRODUCTION

The relationship between the chemical composition and the seasonal fluctuations of phytoplankton has been investigated in many types of natural water habitats, both fresh and saline. This problem, however, has not been sufficiently dealt with in regard to artificial fish ponds.

Investigations dealing with this relationship, with a view to determining the effect on fish yields, are usually carried out in experimental ponds under controlled conditions (fertilizers and fish foods). The present investigation proposes to examine this relationship in ordinary fish breeding ponds where the day to day management is not interfered with in any way.

* This report is an abridged translation of a Doctorate thesis submitted to the Senate of The Hebrew University of Jerusalem.

Received January, 1953

The chemical constituents considered in this investigation were nitrogen, phosphorus and silicon. Nitrogen was examined as ammonia, nitrites and nitrates; phosphorus as phosphates, and silicon as silica. Plankton samples were collected at regular intervals, and the monthly changes in the composition and quantity were compared with the results of the chemical and physical analyses of the water. By this procedure it was intended to establish:

a) The relationship between the seasonal fluctuations of the above mentioned chemical constituents of the water in the fish ponds and the phytoplankton.
b) The characteristic features of the phytoplankton in the three groups of fish ponds.
c) The specific environmental requirements of the main phytoplankton systematic groups, with special attention to some of the most important species.
d) The effect of the various fertilizers, as normally administered to the ponds, on phytoplankton productivity, and the determination of those fertilizers which would be most conducive to the development of beneficial plankton algae for fish breeding.

REVIEW OF LITERATURE

Wiebe (1930) stressed the importance of phosphorus in the production of plankton and considered nitrogen to exist already in sufficient concentration within the ponds. Prescot (1939) emphasized the importance of nitrate nitrogen in the production of phytoplankton. Pennington (1942) found that plankton algae are able to assimilate ammonia nitrogen more readily than nitrate nitrogen. Chu (1942, 1943) maintained that ammonia and nitrate nitrogen are equally utilized by phytoplankton, though nitrates are more readily utilized in low concentrations. Rodhe (1948) found that phosphorus is utilized in varying degrees by different species of plankton algae and that a nitrate deficiency is likely to arrest the development of chlorophyll, although the cells may still continue to multiply for a number of weeks. In his opinion, the quantity of nitrogen present in natural waters often falls below the requirements of some of the more common species of fresh water algae, such as *Scenedesmus quadricauda*.

Pearsall (1932) found that a close relationship exists between the chemical composition of the water and of the phytoplankton. He found that diatoms reach their peak development when the waters are richest in nitrates, phosphates and silica. Blue-green algae, on the other hand, show a general correlation with high concentrations of organic matter in the water and are able to grow in the presence of minimum quantities of nitrates and phosphates.

Hutchinson (1941, 1944) contends that the chemical changes taking place in lake waters have only an indirect effect on the development of phytoplankton. He also considers such factors as: a) presence of specific organic substances in the water, b) inorganic nutrients other than N,P, and Si, c) the physiological condition of the plankton organisms, d) competitive relationships between the different components of phytoplankton to be determinative agents of phytoplankton periodicity.

Lefèvre (1948 a, b) carried further this physiological approach to the problem, maintaining that the changes taking place in phytoplankton are caused not so much by competitive relations for the common available food, as by a state of compatibility

or non-compatibility for coexistence among the various components of a population. This author found the source for this compatibility or non-compatibility in the ability of certain plankton algae to secrete organic substances in the water which can have a neutral, favourable or retarding effect on the development of other algae.

The importance of proper pond fertilization in increasing the productivity in fish yields has been emphasized (Swingle 1947, Ball, 1949, Neess, 1949).

In this country the study of phytoplankton was taken up by Rayss and Katchalsky (1938) and later on by Rayss (1942, 1951), Komarovsky (1951) and Shelubsky (1951).

The outbreak of a fish disease caused by the phytoflagellate *Prymnesium parvum* prompted an intensive investigation into the nature of the toxin. Reich and Aschner (1946, 1947) succeeded in finding a method of control for this fish disease, which was a serious menace to fish breeding in the affected areas. The epidemiological aspect of the disease and the seasonal distribution of this phytoflagellate was examined by Komarovsky (1949) in the Jordan and Beisan Valleys and the Haifa Bay area.

MATERIAL AND METHODS

Field work

Plankton and water samples were collected at intervals of four to six weeks.

The plankton was collected by filtering 20 litres of water from the pond through a small plankton net made of bolting silk No. 25. Care was taken to secure a representative sample by filtering successive samples of water taken along a line running from the west to the east side of the pond. The plankton thus collected was transferred quantitatively to 100 cc calibrated bottles and was preserved by adding an amount of formalin to the water of the collecting bottle to make up a 4% solution.

The temperature of the water was recorded at the surface and at a depth of 30 cm, transparency was determined with a small Secchi disc and pH values were recorded. Separate water samples were also collected for dissolved oxygen determinations.

Laboratory tests

The plankton samples were first examined qualitatively in order to make up the list of the algal population of the pond at the time of collection. Then, after thoroughly mixing up the sample, portions of the material were transferred to counting chambers for quantitative determinations. Two counting chambers were used, one with a volume of 0.1 mm^3 of the "Thomma" type used for blood counts, and the other with a volume of 0.5 cm^3 and 1 mm depth covered by a thick glass marked with 1 mm squares.

The first chamber was used for counting unicellular and colonial algae, and the second was used mostly for counting larger and scarcer organisms like filamentous algae which cover a wider area. In both cases the number of organisms of the individual species was calculated per litre of pond water.

The chemical tests for inorganic nitrogen, such as ammonia, nitrites and nitrates, phosphorus and dissolved oxygen, were carried out in conformity with "Standard Methods for the Examination of Water and Sewage" (1946), while silica was determined accordingly to the method described by Suckling (1944).

The phytoplankton determinations were carried out in accordance with Pascher's

"Die Suesswasserflora Deutschlands, Oesterreichs und der Schweiz" (Hefte: 2, 3, 4, 5, 6, 9, 10, 11, 12), Smith, G. M. (1920, 1924, 1933) and Tilden, J. (1910).

DESCRIPTION OF THE PONDS AND TOPOGRAPHY OF THE AREA

This study was undertaken of six fish ponds, two from each of three fish breeding centres, scattered over a wide area in the Beisan Valley which extends to the west of the Jordan River, south of Lake Tiberias. These ponds are supplied with water from three sources, each of different salinity ranging from 250 to 1000 mg/l Cl in chlo-

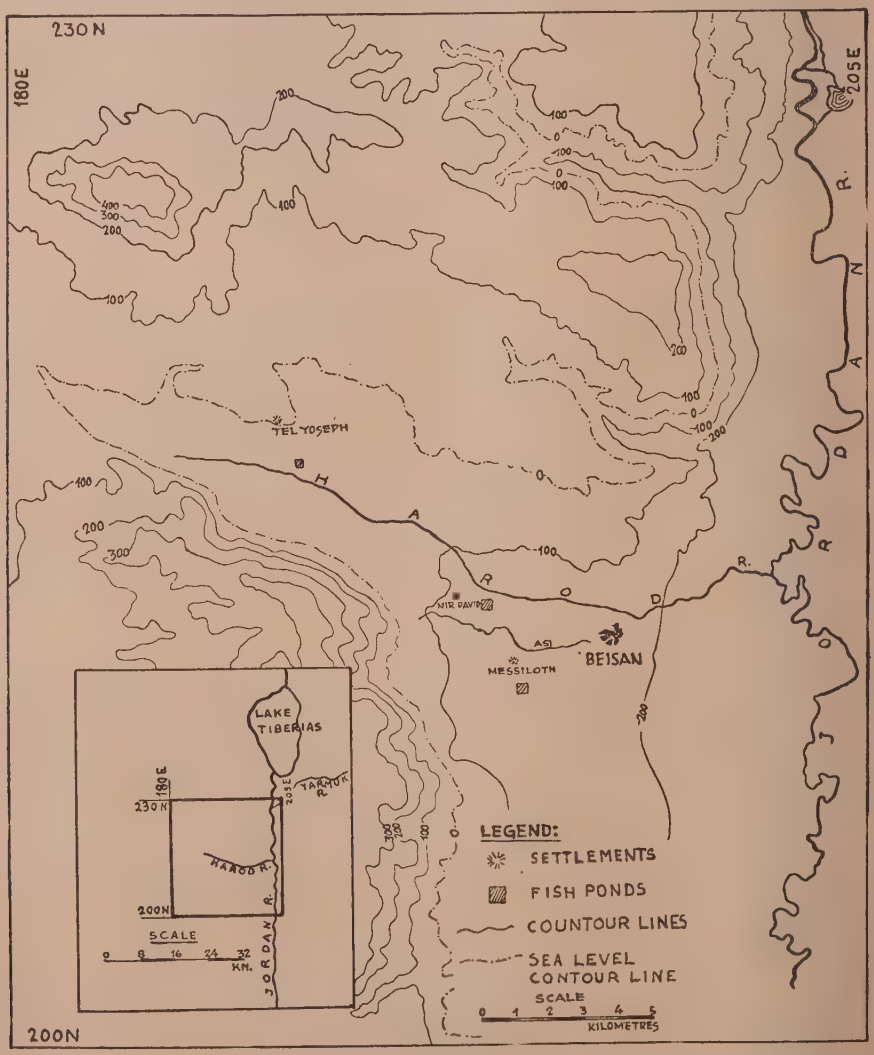

Figure 1
Position of the Ponds in the Beisan Valley

TABLE I

Settlement	*Local name*	*Area (ha.)*	*Type of soil**	*$CaCO_3$** (%)	*Water source*	*Salinity (mg/l Cl)*	*MSL*
1) Nir-David	Tayun A	6.8	Gray calcareous soil	23—27	El-Asi	1000	—110
2) " "	70A	5.0	"	"	"	"	"
3) Messi'oth	12	3.8	"	59—64	Jamain	450	—112
4) "	13	3.5	"	"	"	"	"
5) Tel-Joseph	B	1.0	Alluvial terra-rosa	15—20	Harod	250	—50
6) "	D	2.2	"	"	"	"	"

* Data supplied by the Division of Soil Chemistry, Agricultural Research Station, Rehovot.

rides. They are all situated below sea level in a depression which gradually slopes eastwards towards the Jordan River.

The climate is typical of semiarid zones. Very strong heat-waves prevail during the summer, and the temperature of the water in the ponds often exceeds 30°C during the day. The nights are generally much cooler, with a sharp difference between day and night temperature. The rainy season begins at the end of the fall and lasts till April-May. The dry season then sets in for about six to seven months, when there is no precipitation whatever.

The soil in this area is generally loamy with a varying concentration of lime which in some sectors reaches over 60% (See Table I).

These ponds were all subjected to intensive fertilization with chemical and organic fertilizers in accordance with the accepted practice. The fish were fed with fish foods available on the local market.

Special mention should be made of the use of ammonium sulphate as fertilizer and as a means of controlling the harmful *Prymnesium* blooms which develop in ponds of high salinity (Reich and Aschner 1946, 1947). The fertilizer was administered to the pond at an average concentration of 1:100,000 as soon as the first signs of fish toxicity became noticeable. Very often this procedure had to be repeated several times monthly in view of the recurrence of the *Prymnesium* blooms at frequent intervals.

This paper gives only the data relating to the fertilization of the ponds as directly bearing on phytoplankton productivity as well as short notes on the breeding seasons and fish stocking. The other records connected with the general management of the ponds are not included but may obtained on request.

THE NIR-DAVID PONDS

Pond Tayun A

The pond was filled with water on October 18th, 1948 after being kept dry for 18 days. On the same date it was also stocked with fish at a rate of 2900 per ha. (average weight of fish 75 g). It was drained on May 24th, 1949, and three days later it was refilled with water for the next breeding season. The fish were introduced on June 1st at a stocking rate of 3230 per ha. (average weight 20 g). On July 31st the fish reached an average weight of 300 g. The pond was drained again on July 15th and refilled and stocked with fish on July 24th (average weight 40 g). On September 23rd, the fish averaged 170 g in weight.

Salinity

At the time of filling the pond with water, the salinity of the pond-water almost coincided with that of the water source; during the summer, however, owing to the increased rate of evaporation, the salinity of the pond-water increased rapidly, reaching 1700 mg/l Cl in the month of August. It is just at this time of year that *Chaetoceros muelleri*, a plankton diatom with higher salinity requirements, makes its appearance in the plankton of the pond.

Transparency

The transparency of the water reaches its lowest level in the summer months (10 cm) as a result of the mass development of the blue-green algae and diatoms.

TABLE II

Fertilization of Pond Tayun A

Date	Number of Prymnesium outbreaks	Fertilizer	Quantity (per ha.) kg	Quantity (per ha.) m^3
1948				
October	—	Poultry manure		1.4
November	—	—		
December	—	—		
1949				
January	2	Ammonium sulphate	300	
February	1	" "	200	
March	1	" "	235	
"	2	Superphosphate (30% P_2O_5)	44	
April	2	Ammonium sulphate	325	
"		Superphosphate (45% P_2O_5)	60	
May	—	"	96	
June	—	"	90	
July	—	"	44	
"	1	Ammonium sulphate	60	
August	—	Superphosphate (15% P_2O_5)	250	
September	2	Ammonium sulphate	235	

TABLE III

Physical and chemical (mg/l) characteristics of the water in Pond Tayun A

Date	Hour	Temp. °C	NH_3-N	NO_2-N	NO_3-N	Total Inorganic N	PO_4	SiO_2	Cl	O_2	pH	Transp. (cm)
1948												
19.X,	9.30 a.m.	21.0 20.5	traces	0.15	2.64	2.79	traces	8.0	1100	11.8	7.8	35
13.XI,	—	—	0.34	traces	0.10	0.44	0.05	—	—	—	—	—
28.XII,	9.15 a.m.	15.0 14.8	traces	0.01	0.29	0.30	traces	5.0	910	9.15	6.5	17
1949												
28.I,	4.30 p.m.	15.2	2.50	1.00	—	3.50	0.03	traces	970	8.00	6.1	25
7.III,	9.30 a.m.	14.5 14.0	7.60	0.04	0.20	7.84	0.30	3.5	900	8.55	6.4	20
12.IV,	9.30 a.m.	19.5	1.12	0.03	0.25	1.40	—	10.0	1040	—	8.2	25
1.VI,	5.00 p.m.	29.0	0.74	traces	0.07	0.81	0.06	7.0	1180	—	8.3	29
12.VII,	8.30 a.m.	27.0	0.16	traces	0.02	0.18	0.14	—	—	8	—	10
15.VIII,	—	—	2.40	0.03	0.26	2.69	traces	4.0	1700	—	—	—
13.IX,	3.00 p.m.	28.5	4.50	0.22	0.48	5.20	0.50	8.0	1354	—	8.0	15

Temp.: Upper figure = temp. at depth of 5 cm, lower at depth of 30 cm; when no difference exists only one figure is given.

Phytoplankton. Notes on the seasonal distribution of the main algal groups

TABLE IV

Relative abundance in the plankton of the main algal groups in Pond Tayun A

Algal groups	*No. of species*	*%*
DIATOMEAE	23	34.34
CHLOROPHYCEAE	21	31.35
CYANOPHYCEAE	12	17.91
EUGLENINAE	7	10.45
CONJUGATOPHYTA	3	4.45
CRYPYOMONADINAE	1	1.50
	67	100.00

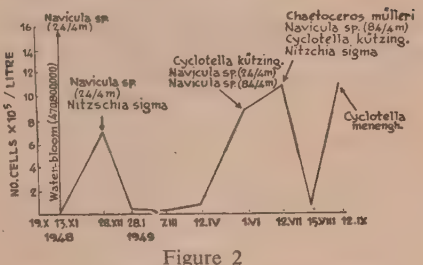

Figure 2

Monthly fluctuations in diatom abundance in Pond Tayun A.

DIATOMEAE. The diatoms were found to be richer in species than any other group of phytoplankton, although not the most abundant. Most conspicuous was the perennial occurrence of two species of *Cyclotella*, *C. kuetzingiana* and *C. meneghiniana*, which form the diatom peak in the summer months. Another peak in diatom development was reached in December, consisting of *Nitzschia sigma* and a minute species of *Navicula*. Two months previously, in October 1948, the same species of *Navicula* was found in enormous concentrations in the plankton at a times when the nitrate nitrogen was in high concentration (2.64 mg/l). This bloom almost disappeared during the following month, when the nitrate nitrogen dropped to a minimum (see Table III).

The presence of *Amphiprora paludosa* and *A. ornata* is also recorded in the plankton, both species being generally found in ponds situated on marshy soil.

It was found that during the diatom peaks in winter and summer the silicon content of the water dropped considerably, while during the subsequent decline in the spring and fall the silicon content became correspondingly restored.

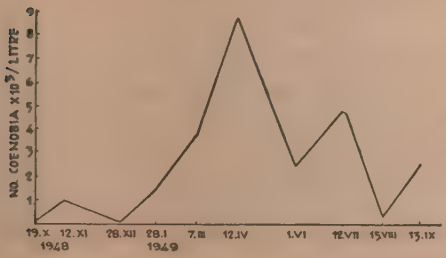

Figure 3

Monthly fluctuations in the abundance of *Scenedesmus quadricauda* in pond Tayun A.

CHLOROPHYCEAE. The Chlorophyceae are represented in this pond chiefly by Protococcales. While algae of this group are rich in species, only a few of them are perennial in their occurrence or develop in greater numbers. One of them is *Scenedesmus quadricauda* which has a most irregular occurrence in the plankton throughout the year, as can be seen from Figure 3.

During October and December, 1948, this alga dropped to mere traces, while a peak in its development was gradually reached in the month of April, 1949. These abrupt fluctuations in the occurrence of *Scenedesmus quadricauda* might be related to the changes in the concentration of ammonia nitrogen in this pond which could even constitute a limiting factor in its development as for example during October and December, 1948, when this constituent fell to its lowest concentrations (see Table II). It is not known, however, whether ammonia nitrogen is the only factor involved in

the distribution of *Scenedesmus quadricauda*, as during the same months the phosphate content of the pond water was equally at its lowest level (traces). It is equally possible that this organism develops in higher numbers during the following months (January—September, 1949) as a result of the considerable rise in the ammonia nitrogen content of the water, although its distribution is by no means proportionate to the actual level of this constituent.

On the whole, the Protococcales reach their peak development in summer, following the laws of seasonal distribution in algal populations (Pearsall, 1932) and thereafter gradually decrease in numbers in fall and winter.

The only representative of the Volvocales was an undetermined species of Chlamydomonas, which formed an ephemeric water-bloom in this pond in the month of June (455,000 organisms per litre).

CONIUGATOPHYTA. The Conjugatophyta are represented by one representative of Desmidiaceae, Closterium, and two species of Zygnemataceae, Mougeotia and Spirogyra. Traces of the first are recorded in September, while the latter appear in higher numbers (Mougeotia 5,250 filaments per litre in March, and Spirogyra 750 filaments per litre in April) during the rainy season only.

CYANOPHYCEAE. The blue-green algae form a major element in the composition of phytoplankton. They produce heavy water-blooms in the summer months in the form of thick scums on the surface of the pond water and below it.

The most frequent bloom-producing organism is *Synechocystis aquatilis*, an inconspicuous unicellular alga often appearing in clusters of two or three cells joined together in very high numbers (Komarovsky 1951).

In respect of the number of species, the ratio between Chroococcales and Hormogonales is 1:1. It should be noted that the blue-green algae reach their maximum development in the pond-plankton in summer, when the phosphate and nitrate content of the water is at its lowest level, thus confirming Pearsall's findings in this respect (1932).

EUGLENINAE. The Eugleninae form a minor element in the composition of the plankton in this pond, except in the month of September, when one of its species—namely *Euglena granulata*—multiplies greatly (2,500 organisms per litre). The same species has been recorded in similarly high counts in the other ponds examined by the author at the same time of the year. It appears that this organism always develops when the pond-water is particularly rich in organic matter as a result of the decay of the blue-green algae which sets in after their peak is reached in the summer months.

Pond 70a

The pond was filled with water on October 4th, 1948 and stocked with fish at a rate of 3000 per ha. (average weight of fish 50 g). Prior to this the pond was kept dry for ten days. It was drained on April 10th, when the fish reached an average weight of 320 g.

A fortnight later, the pond was refilled with water and restocked with fish at a rate of 2600 per ha. (average weight of fish 110 g). On July 7th, the fish were withdrawn after reaching an average weight of 700 g. On July 24th, a third breeding season was started, when 50 g fish were stocked in the pond at a rate of 4550 per ha.

TABLE V

Fertilization of Pond 70 A

Date	Number of Prymnesium outbreaks	Fertilizer	Quantity (per ha) kg	Quantity (per ha) m^3
1948				
October	—	Poultry manure		2
November	—	—		
December	3	Amonium sulphate	500	
1949				
January	1	" "	200	
February	—	—	—	
March	—	—	—	
April		Superphosphate (45% P_2O_5)	50	
May	—	" "	100	
"	—	Cow manure		5.2
June	—	Superphosphate (45% P_2O_5)	40	
July	1	Ammonium sulphate	60	
"		Superphosphate (15% P_2O_5)	220	
August	2	Ammonium sulphate	260	
"		Superphosphate (15% P_2O_5)	160	
September	1	Ammonium sulphate	160	

TABLE VI

Physical and chemical (mg/l) characteristics of the water in Pond 70A.

Date	Hour	Temp. °C	NH_3-N	NO_2-N	NO_3-N	Total Inorganic N	PO_4	SiO_2	Cl	O_2	pH	Transp. (cm)
1948												
12.X,	9.30 a.m.	21.0	0.24	traces	0.10	0.34	traces	2	1130	13.85	7.9	20
13.XI,	3.00 p.m.	21.0	0.12	0.07	0.33	0.52	0.06	—	1250	5.26	7.8	12
28.XII,	8.45 a.m.	14.0	2.00	0.03	0.22	2.25	traces	5.2	952	6.00	6.5	21
1949												
28.I,	4.30 p.m.	15.2	2.50	0.25	—	2.75	0.03	traces	970	—	6.1	30
7.III,	9.30 a.m.	15.2 14.5	—	6.03	0.40	6.43	0.03	1.6	810	—	6.6	32
1.VI,	4.00 p.m.	—	0.74	traces	0.03	0.77	0.12	7	1200	—	8.3	6
15.VIII,	—	31.5	1.00	0.02	traces	1.02	traces	2	1500	—	—	10
13.IX,	3.45 p.m.	29.0	7.00	traces	0.66	7.66	0.25	4	1644	—	8.3	15

Temp.: Upper figure = temp. at depth of 5 cm, lower at depth of 30 cm; when no difference exists only one figure is given.

Phytoplankton. Notes on the seasonal distribution of the main algal groups

DIATOMEAE. As can be clearly seen from Figure 4, the main diatom pulse was found to take place in summer, from June to October. In these months the diatoms form veritable water-blooms.

Of the 13 species of diatoms recorded in the phytoplankton of this pond, only a few of them, such as *Cyclotella kuetzingiana* and *C. meneghiniana*, have a perennial occurrence. Other diatoms were found in the plankton only during the seasonal peaks, such as *Nitzschia sigma* and *Chaetoceros muelleri*.

TABLE VII

Relative abundance in the plankton of the main algal groups

Algal groups	*No. of species*	*%*
CHLOROPHYCEAE	18	38.30
DIATOMEAE	13	27.65
CYANOPHYCEAE	10	21.30
EUGLENINAE	5	10.63
CONJUGATOPHYTA	—	—
CRYPTOMONADINAE	1	2.12
	47	100.00

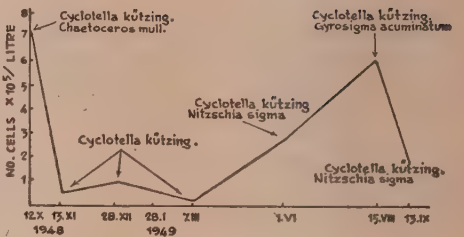

Figure 4

Monthly fluctuations in diatom abundance in pond 70 A.

The existence of an inverse correlation between diatom abundance and the silicon and nitrate nitrogen concentration which was observed in the neighbouring pond Tayun A has been further confirmed by the data collected on the plankton and water analyses of this pond.

The ammonia nitrogen content of the water, which was found to be exceptionally high in this pond (7 mg/l in September) as a result of the frequent applications of ammonium sulphate for the purpose of *Prymnesium* control, seemed to have little or no effect on diatom periodicity.

Furthermore, no clear relationship could be established either between the fluctuations in the phosphate content of the water, which was unnaturally high because of the heavy administration of superphosphate fertilizer, and the plankton periodicity.

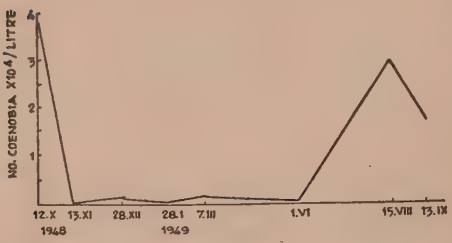

Figure 5

Monthly fluctuations in the abundance of *Scenedesmus quadricauda* in Pond 70 A.

CHLOROPHYCEAE. Most of the Chlorophyceae recorded in the phytoplankton of this pond occur only in low numbers. All the species belong to Protococcales and of these only *Scenedesmus quadricauda* is truly perennial. This organism reaches its peak development, between August and October, and in the latter month a concentration of 37,500 coenobia per litre of pond water is attained. This figure is about some four times as high as that recorded for the same organism in the neighbouring pond Tayun A during April, 1949.

No clear relationship can be traced between the seasonal distribution of *Scenedesmus quadricauda* and the changes in the concentration of the chemical constituents considered in this investigation.

CYANOPHYCEAE. The blue-green algae are almost entirely absent from the plankton during the winter months, from November till March. In June they start to develop in greater abundance, producing the typical blooms which last till October. The ratio of Hormogonales to Chroococcales in the plankton of this pond is 2:1. The most important species of blue-green algae recorded in the plankton of this pond are: *Synechocystis aquatilis*, *Microcystis flos aquae* and *Aphanocapsa pulchra*. *Microcystis*

aeruginosa, which is one of the most common algae in the plankton of truly fresh water ponds, was not recorded in the plankton of the Nir-David ponds, which have a relatively high salinity.

EUGLENINAE. In this pond, the Eugleninae form only a minor element in the composition of the plankton, at least from a quantitative point of view. *Euglena oxyuris* occurred in high concentration in October and November, 1948, coinciding with the fertilization of the pond with poultry manure while *Euglena granulata* occurred in August when the water was particularly rich in organic matter, due to the decay of blue-green algae.

THE MESSILOTH PONDS

Pond 12

TABLE VIII

Fertilization of Pond 12

Date	*Fertilizer*	*Quantity (m^3 per ha)*
1948		
October	Poultry manure	0.26
December	Poultry manure	1.32
1949		
May	Poultry manure	1.32
July	Poultry manure	0.66

The pond was stocked with 30 g fish in August, 1948, at a rate of 12,000 fish per ha. At the end of October, the fish already weighed 255 g and a month later when the pond was drained they weighed 310 g. During this whole breeding season, the yield was 5,500 kg of fish.

The pond was refilled with water on December 10th and restocked with 18 g fish on the same date, at a rate of 12,800 per ha. It was drained at the beginning of June, the total fish yield being 6,500 kg for the whole season.

The next breeding season started in June, 25th when the pond was stocked with 150 g fish at a rate of 300 per ha. On July 15th, the fish weighed already 360 g and on August 11th, 440 g.

TABLE IX

Physical and chemical (mg/l) characteristics of the water in Pond 12

Date	*Hour*	*Temp. °C*	*NH_3-N*	*NO_2-N*	*NO_3-N*	*Total Inorganic N*	*PO_4*	*SiO_2*	*Cl*	*O_2*	*pH*	*Transp. (cm)*
1948												
22.X.	3.00 p.m.	27.5	0.10	0.017	0.11	0.227	0.17	10	433	15.92	7.9	12
28.XII.	2.00 p.m.	16.0	0.12	0.032	0.10	0.252	traces	traces	420	14.41	6.4	40
1949												
28.I.	—	16.5	1.80	0.040	traces	1.870	0.03	traces	320	15.60	7.2	40
8.III.	—	17.5	1.00	0.040	0.30	1.340	—	4	370	—	6.5	40
		17.0										
12.IV.	0.30 p.m.	25.0	0.48	0.022	0.16	0.662	—	14	390	—	8.2	50
1.VI.	3.00 p.m.	32.5	1.00	0.055	0.35	1.055	0.02	20	410	12.12	9.0	15
11.VII.	12.00 n.	30.0	0.34	0.016	0.26	0.616	0.04	10	430	19.35	—	15
15.VIII.	10.00 a.m.	29.5	—	0.010	traces	0.010	0.02	12	430	—	8.5	23
13.IX.	11.00 a.m.	26.0	1.00	0.060	0.94	2.000	0.34	15	432	—	7.8	—
		25.5										

Temp.: Upper figure = temp. at depth of 5 cm, lower at depth of 30 cm; when no difference exists only one figure is given.

Phytoplankton. Notes on the seasonal distribution of the main algal groups

DIATOMEAE. The analysis of the seasonal distribution of the diatoms in this pond has revealed again the existence of two distinct pulses, in their abundance, one in summer and the other in winter.

TABLE X

Relative abundance in the plankton of the main algal groups

Algal groups	*No. of species*	
CHLOROPHYCEAE	24	35.0
DIATOMEAE	18	26.0
CYANOPHYCEAE	16	23.2
CONJUGATOPHYTA	4	5.8
EUGLENINAE	4	5.8
HETEROKONTAE	1	1.4
PERIDINEAE	1	1.4
CRYPTOMONADINAE	1	1.4
	69	100.0

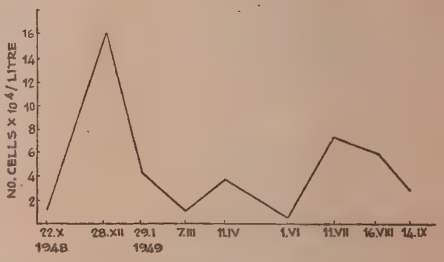

Figure 6

Monthly fluctuations in diatom abundance in Pond 12.

Only a few of the species recorded in the plankton of this pond have a perennial existence and constitute an important factor from a quantitative point of view. Of these, *Cyclotella kuetzingiana* should be mentioned as the most common organism, followed by *Cyclotella meneghiniana* which occurs in lower numbers than the former during the greater part of the year.

Amphiprora paludosa is found in this pond as well as in the Tayun A, both ponds being situated in marshy areas. During the winter and summer peaks in diatom periodicity, the silicon content of the water dropped to traces. The concentration of nitrate nitrogen is equally exhausted during the winter diatom pulse.

CYANOPHYCEAE. The Cyanophyceae increased in abundance in October, 1948 and in the summer months of 1949, especially in June and July.

No clear relationship could be established between the distribution and periodicity of the Cyanophyceae and the fluctuations in the concentration of inorganic nitrogen and phosphorus in this pond. The phosphate content of the water, for example, was found to be 0.17 mg/l during the first peak recorded in October, 1948, while during the considerably higher peak recorded in the summer months of the following year its concentration was as low as 0.02—0.04 mg/l (see Table IX).

It should be borne in mind that both peaks in the abundance of the blue-green algae occurred after the fertilization of the pond with poultry manure in October, May and July (see Table VIII). It is assumed therefore that the blue-green algae found favourable conditions for increasing their abundance, as a result of the rise in the organic matter content of the water.

The species of blue-green algae which are of perennial occurrence were *Microcystis aeruginosa* and *M. flos aquae*. Mention should be made of *Synechocystis aquatilis* which became very abundant in June and July, 1949.

Of the nine species of Hormogonales recorded in the plankton, *Oscillatoria annae* and *Spirulina platensis* were the most abundant. Their maximum was in August, 1949, with a concentration of 51,000 and 42,500 filaments per litre respectively.

CHLOROPHYCEAE. The proportion of green algae in the composition of the phytoplankton is remarkably high. They are represented by 24 different species and varieties and constitute 35% of the total number of species recorded in the plankton of the pond (see Table X). All but one of these species belong to Protococcales. At the peak of their development, the concentration of green algae jumped to 127,500 organisms per litre in July and 60,000 in September as compared with 750 in March, the time of their lowest concentration, as can be seen from the following figure.

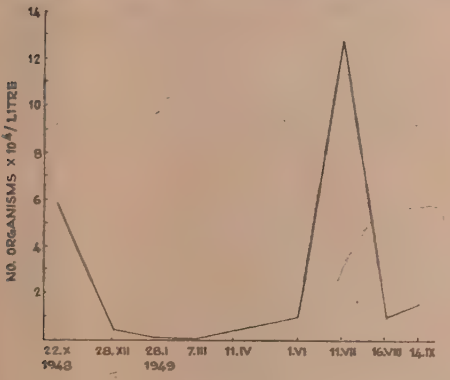

Figure 7
Monthly fluctuations in the abundance of Protococcales in Pond 12 Messiloth

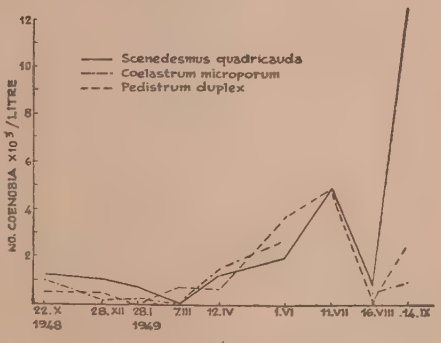

Figure 8
Monthly fluctuations in the abundance of *Scenedesmus quadricauda*, *Coelastrum microporum* and *Pediastrum duplex* in Pond 12 Messiloth

A similar trend in distribution and periodicity is followed by two other important plankton algae belonging to Protococcales, namely *Coelastrum microporum* and *Pediastrum duplex*, as can be seen from Figure 8.

A strongly polymorphic species appearing in the phytoplankton of this pond is *Ankistrodesmus falcatus*. Of the different varieties of this species, *Ankistrodesmus falcatus v. acicularis* has a perennial distribution in the plankton, attaining a maximum in July, 1949 (7,500 cells per litre). *Ankistrodesmus falcatus* var. *mirabile*, which was sporadically recorded in the monthly plankton samples, developed a maximum in October, 1948 (56,000 cells per litre).

EUGLENINAE. *Euglena granulata*, which has a perennial distribution, attained enormous concentrations in September, 1949 (over 2,000,000 cells per litre), while *Euglena ehrenbergii* likewise reached its peak in the same month, although it was found in much lower concentrations. These peaks are reached in September, when the organic content of the water is at its highest.

CRYPTOMONADINAE. The same is true of *Cryptomonas erosa*, whose highest peak was recorded in August and September, 1949.

Pond 13

The pond was filled with water on August 24th, 1948 and stocked with 30 g fish at a rate of 5,600 per ha. The fish increased rapidly in weight during the following months,

TABLE XI

Fertilization of Pond 13

Date	*Number of Prymnesium outbreaks*	*Fertilizer*	*Quantity (per ha)*	
			kg	m^3
1948				
September	—	Poultry manure		0.85
October	1	Ammonium sulphate	85 7	
1949				
May	—	Poultry manure		1.14

reaching 400 g at the end of November. During this whole breeding season, 18,320 fish were taken out with a total weight of 5,640 kg.

The pond was restocked with fish on January 9th, 1949 when 35,000 fry with an average weight of 10 g were introduced. This breeding season lasted until July 5th, when the pond was drained. During this period the total fish yield was 6,542 kg. On July 13th the next breeding season was started the pond being stocked with 2,000 fish with an average weight of 30 g.

TABLE XII

Physical and chemical (mg/l) characteristics of the water in Pond 13.

Date	*Hour*	*Temp. °C*	NH_3-N	NO_2-N	NO_3-N	*Total Inorganic N*	PO_4	SiO_2	*Cl*	O_2	*pH*	*Transp. (cm)*
1948												
22.X,	4.00 p.m.	27.0	0.10	0.010	0.04	0.15	traces	10	550	25.44	7.9	22
25.XI,	3.30 p.m.	17.5 18.0	0.26	traces	0.06	0.32	traces	2	522	11.50	7.4	17
28.XII,		16.0	0.06	traces	0.03	0.09	traces	traces	420	10.94	6.5	42
1949												
28.I,	5.00 p.m.	16.0	1.80	traces	t	1.80	0.03	traces	430	70.30	7.2	40
1.VI,	4.00 p.m.	—	0.88	traces	0.30	1.18	0.18	9	480	12.14	7.8	16
11.VII,	4.15 p.m.	30.0	0.28	traces	t	0.28	0.04	8	475	—	—	15
15.VIII,	8.45 a.m.	28.5	1.50	0.025	0	1.53	0.02	13	490	—	8.5	23
13.IX,	10.15 a.m.	25.0	1.40	traces	0.94	2.34	0.46	10	580	—	8.8	6

Temp.: Upper figure = temp. at depth of 5 cm lower at depth of 30 cm; when no difference exists only one figure is given.

Salinity

The salinity of the pond fluctuated within relatively narrow limits, between 420 and 580 mg/l, the former during the high precipitation period and the latter during the dry period.

Transparency

The transparency was found to be higher in winter owing to the comparatively weak development of phytoplankton. During the summer, however, several algal groups developed simultaneously in high concentrations thereby lowering the transparency figures.

Phytoplankton. Notes on the seasonal distribution of the main algal groups

DIATOMEAE. The number of diatom species recorded in the plankton of this pond is smaller than in pond 12 situated in its immediate neighbourhood. Nevertheless, the curves indicating the fluctuations in the abundance of diatoms in both ponds are very similar.

TABLE XIII

Relative abundance in the plankton of the main algal groups

Algal groups	*No. of species*	
CHLOROPHYCEAE	25	48.00
CYANOPHYCEAE	13	25.00
DIATOMEAE	6	11.40
EUGLENINAE	3	5.60
HETEROKONTAE	2	4.00
CRYPTOMONADINAE	1	2.00
CONJUGATOPHYTA	1	2.00
PERIDINEAE	1	2.00
	52	100.00

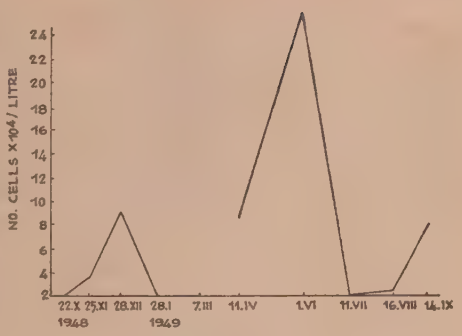

Figure 9

Monthly fluctuations in diatom abundance in Pond 13 Messiloth

Here, too (as in the plankton of Pond 12), there was a distinct peak in diatom productivity in December, 1948, followed by a second peak in April, 1949 and a third one in September, 1949. All these peaks in diatom productivity were produced by *Cyclotella kuetzingiana* and by *C. meneghiniana* to a lesser degree. The other organisms present appear only in traces.

The inverse correlation between diatom pulses and the concentration of silica and nitrates in the water has been observed in this pond as well. The great pulse in diatom periodicity, which was found to take place in December, caused a substantial drop in the concentration of silica down to mere traces. The nitrate nitrogen, on the other hand, which was on the increase during the same peak in diatom distribution dropped also to mere traces in the subsequent month, suggesting that the diatoms have used it up during their bloom period. The same phenomenon took place in summer, when the drop in nitrate nitrogen occurred after the June peak in diatom periodicity. It is possible, however, that the sudden drop in diatom concentration in July came as a result of the draining and the subsequent refilling of the pond with water and not as a result of natural factors.

CYANOPHYCEAE. Summer and fall were found to be the seasons of greatest blue-green algal development. During June and July the phytoplankton was dominated by *Synechocystis aquatilis*, whose occurrence was not interrupted even by the draining and refilling of the pond in the latter month.

The two common species of *Microcystis*, *Microcystis flos aquae* and *M. aeruginosa*, were present almost throughout the year. So was *Aphanocapsa pulchra*, which became more abundant in summer.

In fall, the blue-green algal flora was dominated by Hormogonales, especially by *Anabaena* and *Anabaenopsis*. Other common species encountered in the plankton were *Spirulina platensis*, *Oscillatoria formosa* and *O. annae*.

The natural maximum of this group occurs during the hot summer months, when climatic conditions are favourable to their development and is further stimulated and prolonged by the application of organic fertilizer (see Table X).

CHLOROPHYCEAE. The green algae were found to develop mainly in summer and fall. One peak, occurring in fall, 1948, was composed chiefly of *Ankistrodesmus falcatus*

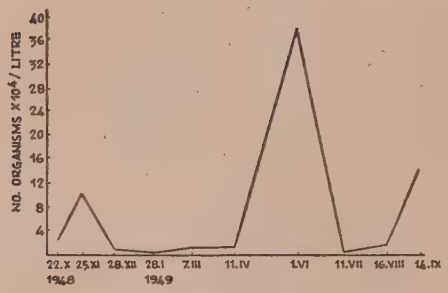

Figure 10
Monthly fluctuations in the abundance of Protococcales in Pond 13 Messiloth

v. *mirabile*, *Actinastrum hantzschii*, and *Scenedesmus acuminatus*. The second peak, occurring in June 1949, was composed of *Actinastrum hantzschii*, *Coelastrum microporum*, *Scenedesmus obliquus*, and *Dictyosphaerium pulchellum*. Of the many species of green algae recorded in the plankton, only a few were found to be truly perennial, such as *Pediastrum duplex* and *Coelastrum microporum*. The other organisms occurring sporadically assure the continuity of green algae in the plankton of the pond throughout the year.

Coelastrum microporum was generally found to require higher concentrations of nitrogen and phosphorus for its development. This was the case in June, 1949, when the ammonia nitrogen, nitrate nitrogen and the phosphates were on the increase (NH_3—N 0.9 mg/l; N—NO_3 0.3 mg/l and PO_4 0.19 mg/l). During this month, *Coelastrum microporum* multiplied rapidly, reaching a concentration of 25,000 coenobia per litre of pond water. After a sudden drop to mere traces in July, there was a rise to 1000 in August and 12,500 in September, following a corresponding though not proportionate increase in the concentration of available nitrogen and phosphorus, as in pond 12.

The genus Scenedesmus, comprising several species in the plankton of this pond, probably has the same environmental requirements as *Coelastrum microporum* in respect of its nitrogen and phosphorus consumption. Of these species, the most important are *Scenedesmus acuminatus* and *S. obliquus*, which reach in July a maximum concentration of 52,5000 and 17,500 coenobia per litre respectively.

The environmental requirements of Heterokontae seem to be similar to those of Chlorophyceae. In June, 1949, when nitrate nitrogen rose to 0.3 mg l and the phosphates to 0.18 mg/l, *Botryococcus braunii* also increased to 60,000 colonies per litre. In September, 1949, when the concentration of nitrates and phosphates in the water was even higher, *Chlorobotrys regularies* also developed to 25,000 colonies per litre.

EUGLENINAE, CRYPTOMONADINAE and PERIDINEAE. The Eugleninae and Cryptomonadinae develop chiefly at the end of the summer, when the water is richest in organic matter. *Euglena granulata* developed a very intense water bloom in September, 1949, which constituted a tremendous increase in its abundance in comparison with the previous month.

During the winter months, the presence of a Peridinean, *Glenodinium cinctum*, was recorded. Its maximum coincided with that of the diatoms at that time of the year. It is interesting to note that the increased winter and spring development of freshwater Dinoflagellates seems to be a characteristic feature of the Jordan Valley plankton, as for example the very high concentration of Peridinium westii, which has been recorded in the winter and spring plankton of Lake Tiberias (Komarovsky 1951).

THE TEL JOSEPH PONDS

Pond B

The pond was filled with water on August 18th, 1948, after being kept dry for 45 days. This water did not come directly from the main water source, but from the neighbouring pond A. It was stocked with fish on November 1st at a rate of 5,200 fish per ha (average weight 110 g). The pond was drained on April 18th, when the fish reached a weight of 215 g. The pond was kept dry until April 24th when it was refilled with water and stocked with 15 g fish at a rate of 10,000 per ha. It was drained again on August 10th.

TABLE XIV
Fertilization of Pond B

Date	*Fertilizer*	*Quantity (m^3 per ha)*
1948		
November	Cow manure	5
November	Poultry manure	10
1949		
January	Cow urine	15
February	Cow urine	30

TABLE XV
Physical and chemical (mg/l) characteristics of the water in Pond B

Date	*Hour*	*T°C*	*NH_3-N*	*NO_2-N*	*NO_3-N*	*Total Inorganic N*	*PO_4*	*SiO_2*	*Cl*	*O_2*	*pH*	*Transp.*
1948												
2.XI,	8.15 a.m.	18.0 17.5	0.08	—	0.10	0.18	—	—	550	7.57	7.7	14
25.XI,	8.00 a.m.	15.4 15.2	0.28	traces	0.05	0.33	traces	2.0	608	5.16	6.7	25
29.XII,	7.15 a.m.	13.0	0.30	0.05	0.05	0.40	traces	4.8	475	8.24	6.6	30
1949												
28.I,	8.00 a.m.	12.0	1.60	traces	traces	1.60	traces	traces	430	3.74	7.4	20
7.III,	11.30 a.m.	30.0	3.60	0.05	0.02	3.67	0.20	2.4	370	—	6.9	30
11.IV,	8.15 a.m.	18.0	3.20	0.03	0.03	3.26	—	6.0	330	—	8.0	15
1.VI,	8.00 a.m.	—	0.90	0.10	0.50	1.50	0.64	10.0	320	—	8.5	8
11.VII,	8.30 a.m.	25.5	0.46	traces	0.15	0.61	0.32	10.0	525	—	—	8
26.VIII,	9.15 a.m.	27.0	1.00	0.18	1.30	2.48	traces	10.0	520	—	9.0	30
14.IX,	11.40 a.m.	26.3	1.20	traces	0.36	1.56	1.04	20.0	587	—	9.0	15

Temp.: Upper figure = temp. at depth of 5 cm. lower at depth of 30 cm; when no difference exists only one figure is given.

Salinity

When the present investigation was undertaken in fall, 1948, this pond was filled with water from the neighbouring pond and not from its regular water source. This accounted for the relatively high salinity of 550 mg/l, which prevailed in the pond water at that time. In the following winter and spring, however, its salinity gradually decreased, dropping to 320 mg/l on the first of June. A steep increase in salinity took place with the beginning of the dry season due to the increased evaporation rate and this continued until the start of the rainy season.

Transparency

The transparency of the water in this pond is determined by heavy algal blooms which are perennial in their distribution. The intensity of these blooms, however, varies:

in summer, when the algal blooms are at their height, the transparency fell as low as 8 cm; in August, after the draining of the pond and the changing of the water, the transparency rose again to 30 cm and it dropped in fall, when the blue-green algae bloomed again.

Phytoplankton. Notes on the seasonal distribution of the main algal groups

TABLE XVI

Relative abundance in the plankton of the main algal groups

Algal group	*No. of species*	
CHLOROPHYCEAE	24	40.66
CYANOPHYCEAE	18	30.50
DIATOMEAE	9	15.24
EUGLENINEAE	4	6.8
CONJUGATOPHYTA	2	3.4
PERIDINEAE	1	1.7
CRYPTOMONADIEAE	1	1.7
	59	100.00

DIATOMEAE. The diatoms play only a limited role in the composition of the phytoplankton, being represented by some nine species and found generally in low numbers. In one case only did a minute species of *Navicula* (24/4 microns) rise to a high concentration of 625,000 cells per litre, in the month of July. Lower concentrations of 6,000—20,000 organisms per litre were recorded for *Cyclotella kuetzingiana* in the fall months. Another commonly known species of diatoms, *Cyclotella compta* was found in this pond and recorded only once, in January 1949, when it reached a concentration of 45,000 organisms per litre.

CHLOROPHYCEAE. The green algae are represented in the plankton by a relatively large number of species constituting over 40% of the total number of species recorded in the phytoplankton of this pond. Most of these algae are, however, of negligible importance from a quantitative point of view. During their peak development in winter they reach concentrations as high as 85,000 organisms per litre (in December, 1948). They progressively diminish in spring and summer, due to the strong competition with the blue-green algae which bloom intensely at this time of the year.

During the December maximum in the distribution of green algae, the dominant species for this group were *Richteriella botryoides* and *Golenkinia radiata.*

Unlike some of the other ponds, it is difficult to explain the fluctuation in the abundance of the green algae in this pond in the light of changes in the concentration of the main dissolved nutrient substances in the water.

CYANOPHYCEAE. The blue-green algae form an almost continuous series of water-blooms in the phytoplankton of this pond throughout the year. This is clearly seen from the following table.

TABLE XVII

Monthly succession of blue-green algae forming characteristic water-blooms in the plankton of the pond.

1948			1949						
October	*November*	*December*	*January*	*March*	*April*	*June*	*July*	*August*	*September*
Spirulina platensis	*Spirulina platensis Anabaenopsis circularis*	*Anabaenopsis circularis*	*Anabaena spiroides*	*Anabaena spiroides*	—	*Synechocystis aquatilis*	*Synechocystis aquatilis*	*Synechocystis aquatilis, Microcystis flos aquae*	*Synechocystis aquatilis, Phormidium molle*

It can be seen from this table that the plankton of the winter months is dominated by species of Hormogonales, while that of the summer months by Chroococcales (Komarovsky 1951).

Of the former, *Anabaena spiroides*, *Anabaenopsis circularis* and *Spirulina plantensis* are the characteristic species, while of the latter *Synechocystis aquatilis* is by far the most common bloom-producing organism.

The continuous series of water-blooms is probably due to the fertilization of the pond with poultry and cow manure in fall, immediately prior to the refilling of the pond with water. In addition, the pond was fertilized with considerable quantities of cow urine in January and February, which noticeably increased the ammonia nitrogen content of the water in that season. The application of these fertilizers might perhaps account for the mass development of blue-green algae in winter and spring, when the low temperature of the water does not, generally favour an unlimited increase in their abundance.

EUGLENINAE. The seasonal distribution of Eugleninae is similar to that of the other ponds examined by us. The occurrence in the plankton of such species as *Phacus pyrum* and *Lepocinclis teres* is characteristic of stagnant waters.

PERIDINEAE. The Peridineae are represented by only one species, namely *Glenodinium neglectum*, which reached a relatively high concentration in March, 1949 (29,000 cells per litre). The occurrence of this peridinian in March is again in accordance with the author's findings on the seasonal distribution of Peridineae in the Jordan water system (1951).

Pond D

The pond was filled with water on August 25th, 1948 and stocked with fish at a rate of 3,600 per ha (average weight of 50 g). It was drained on November 11th when the fish reached an average weight of 310 g. The pond was kept dry for 35 days being refilled with water on December 23rd. Together with the water, fish were introduced into the pond at a rate of 3,640 per ha with an average weight of 30 g.

TABLE XVIII
Fertilization of the pond

Date	*Fertilizer*	*Quantity (m^3 per ha)*
1948		
October	Cow urine	20.0
December	Cow urine	14.0
1949		
January	Cow urine	14.0
January	Poultry manure	1.8
February	Cow urine	14.0

Salinity

The winter rains brought the salinity down to 240 mg/l Cl in March. A gradual increase in salinity took place subsequently throughout summer and fall as a result of the high rate of evaporation.

The appearance of the Zygnemataceae in the plankton of the pond in March and April coincided with the lowest salinity of the water (240 mg/l), thereby indicating the low salinity requirements of these algae.

Transparency

The bloom of the blue-green algae in the summer considerably lowered the transparency

of the water (see Table XIX). The algae causing the water-blooms were *Synechocystis aquatilis*, *Microcystis aeruginosa* and *M. flos aquae*.

TABLE XIX

Physical and chemical (mg/l) characteristics of the water in Pond D.

Date and time	*T°C*	*NH_3-N*	*NO_2-N*	*NO_3-N*	*Total InorganicN*	*PO_4*	*Cl*	*SiO_2*	*O_2*	*PH*	*Transp. (cm)*
1948											
2.XI, 7.05 a.m.	18.0	1.50	0.040	traces	1.540	—	370	—	0.35	7.6	14
29.XII, 8.45 a.m.	13.0	0.20	0.300	traces	0.500	traces	—	4.8	11.43	6.6	60
1949											
20.I, 7.15 a.m.	12.0	2.50	0.160	traces	2.660	traces	430	traces	3.34	7.0	30
7.III, 11.30 a.m.	17.0	0.70	0.036	0.20	0.936	0.22	240	5.0	—	6.4	60
11.IV, 7.30 a.m.	17.5	3.20	—	0.05	3.250	—	260	12.0	—	8.4	12
1.VI, 9.00 a.m.	—	0.80	0.120	0.78	1.700	0.72	260	—	3.76	8.5	—
7.VII, 9.15 a.m.	25.5	0.54	0.002	0.11	0.652	0.16	380	10.0	—	—	—
16.VIII, 9.45 a.m.	27.5	1.50	0.125	traces	1.625	traces	380	10.0	—	7.5	10
14.IX, 12.30 p.m.	26.5	1.60	traces	0.40	2.000	0.58	435	22.0	—	8.4	8

Temp.: Upper figure = temp. at depth of 5 cm, lower at depth of 30 cm: when no difference exists only one figure is given.

Phytoplankton. Notes on the seasonal distribution of the main algal groups

TABLE XX

Relative abundance in the plankton of the main algal groups

Algal groups	*No. of species*	
CYANOPHYCEAE	16	36.35
CHLOROPHYCEAE	13	29.54
DIATOMEAE	8	18.20
CONJUGATOPHYTA	4	9.10
CRYPTOMONADINAE	1	2.27
EUGLENINAE	1	2.27
PERIDINEAE	1	2.27
	44	100.00

DIATOMEAE. The diatoms were found to be represented in this biotope by a smaller number of species than is found in the ponds with higher salinity. Among these species, two typically benthonic diatoms were encountered, *Cymbella affinis* and *Surirella ovalis*, having been caught in the plankton net as a result of the shallowness of the water and its vertical movement.

In the course of the present investigation, it was found that the main peak in diatom development took place in November, 1948. At this peak the concentration of diatoms was found to be 159,000 cells per litre, its main constituents being *Cyclotella kuetzingiana* and several species of *Navicula*. From November, 1948 to February, 1949, the period of the winter maximum, the silica fluctuated between mere traces and 4.8 mg/l; in spring and summer, however, when the diatoms disappeared almost completely from the plankton, the silica increased in concentration and fluctuated from 5 mg/l in March (its minimum) to 22 mg/l in September (its maximum).

The nitrates likewise showed a drop in concentration to 0.2 mg/l during the winter diatom peak and a rise to 0.8 mg/l in June, when the diatoms were at their lowest.

CYANOPHYCEAE. The blue-green algae constitute in this pond, too, the dominant element in the plankton, the Hormogonales appearing chiefly in winter and the Chroococcales appearing both in summer and winter.

An ephemeric occurrence of *Aphanothece saxicola* was recorded in great abundance in March, 1949.

CHLOROPHYCEAE. All the green algae recorded in the plankton of this pond belong to Protococcales. Of these species, *Pediastrum simplex* and *Pediastrum duplex* are the most common, either or both of these species occurring in every monthly plankton sample.

CONJUGATOPHYTA. The Conjugatophyta played a particularly important part in the composition of the flora of this pond on March and April, 1949, when the precipitation was at its highest in this region. They included mostly filamentous algae belonging to Zygnemataceae, besides an undetermined species of *Closterium* found as mere traces in the same season.

EUGLENINAE, CRYPTOMONADINAE AND PERIDINEAE. Of these groups of Phytoflagellates, only *Glenodinium neglectum* was of any quantitative importance in the plankton. This Peridinian reached a maximum of 22,500 organisms per litre in November, 1948, and thereafter it gradually decreased to mere traces in January, 1949, vanishing altogether in the months following.

DISCUSSION

Nitrogen

Inorganic nitrogen exists in natural bodies of water in the form of ammonia, nitrites and nitrates. Of these compunds, only the first and the last have been found to be the main sources of inorganic nitrogen used by plankton algae. The nitrites are, as a rule, chemically unstable and occur in concentrations which are too low to be of any significance in phytoplankton periodicity.

The nitrogen supply varied greatly in the ponds of the three fish-breeding centres, depending on the form of management and the methods and types of fertilization applied in each case.

The Nir-David fish ponds, with the highest salinity (1000 mg/l Cl), were subjected to intensive fertilization with ammonium sulphate in order to control the harmful *Prymnesium* blooms. As a result of this procedure, the ammonia nitrogen content of the water rose to exceptionally high levels, e.g. 7.6 mg/l in March, 1948 in Tayun A, and to 7 mg/l in September, 1949 in pond 70 A (Table III, VI).

In the Messiloth ponds with a lower salinity (400—500 mg/l Cl), the main source of nitrogen supply came from the organic manure with which the ponds were fertilized, while in the low salinity ponds of Tel-Joseph (250 mg/l Cl), the nitrogen supply came from cow urine and poultry manure used as fertilizers.

The inorganic nitrogen was found to have a different and specific effect on the various groups of plankton algae considered in this investigation. This relationship depended mainly on the form in which the inorganic nitrogen existed and its availability to the phytoplankton at any particular time. It was found that some types of plankton algae show preference for the assimilation of nitrogen as nitrates, or as ammonia, while still other can make use of it in both forms.

The diatoms were found to draw heavily on the nitrate supply in the water at the time of their winter and summer maxima. During these peaks in diatom abundance, or soon afterwards, the concentration of nitrates in the water dropped considerably, as did the silica concentration, due to the direct assimilation of the latter by the diatoms for the building up of the cell-wall. This relationship was consistently found to

exist in all the six ponds examined by us and confirms Pearsall's (1932) findings in this respect.

The drop in the concentration of nitrate nitrogen may coincide with the attainment of seasonal maxima in the abundance of diatoms, as was found to be the case in most of the ponds, or it may come a little while afterwards, when the diatoms begin to decline. Such, for instance, was the case in Tayun A, where a particularly intense water-bloom appeared in October, 1948. At that time the nitrate nitrogen content of the water was 2.64 mg/l, which is considered an unusually high concentration in this region. A month later, the nitrate nitrogen dropped to 0.1 mg/l (see Table III and Figure 2), following the peak in diatom abundance.

In pond 70 A (during the peak in diatom abundance in October, 1948 and in the summer of 1949), the nitrate nitrogen concentration dropped together with the silica (see Table VI). The same was found to be true of the two ponds of Messiloth.

Ammonia nitrogen was not found to constitute a limiting or a determinative factor in diatom production. Even when the ammonia nitrogen concentration of the water reached unusually high levels, the production of diatoms in the plankton did not seem to be stimulated thereby. Such, for instance, was the case in pond Tayun A, Nir-David, where the concentration of ammonia nitrogen rose to 7.6 mg/l in March, 1949, as a result of frequent applications of ammonium sulphate. In that month the diatoms disappeared almost completely from the plankton (see Table III and Figure 2). It is not known, however, to what extent the additional supply of nitrogen induced by the administration of fertilizers as distinct from the natural supply in the form of ammonia became indirectly available to phytoplankton through subsequent part conversion to nitrates by means of bacterial action.

With regard to green algae, the nitrogen requirements of several species of Protococcales were considered specifically and the results were compared with those obtained by other investigators. From the data collected in the present investigation, it appears that nitrogen can sometimes be a limiting factor in the distribution and periodicity of these algae. The abundance of *Scenedesmus quadricauda*, for example, seems to be somewhat related to the concentration of ammonia nitrogen in the water. A rise in the concentration of this nutrient substance would occasionally be accompanied by increased growth of *Scenedesmus quadricauda*. This can be seen, for example, from the analysis of data derived from Pond Tayun A, Nir David (see Table III and Figure 3). In some of the other ponds, however, this relationship is less clear as *Scenedesmus quadricauda* occurred in a number of cases in relatively high numbers also during low concentrations of ammonia nitrogen in the water.

Another example of a similar relationship can be seen in the case of *Botryococcus braunii* of the Heterokontae. In June, 1949, this alga rose to 60,000 colonies per litre in Pond 13, Messiloth, at a time when the concentration of nitrate nitrogen rose also to 0.3 m/gl, which is considered by Chu (1943) as being the lower limit for the optimal development of this organism.

Inorganic nitrogen did not prove a limiting factor in the distribution and periodicity of blue-green algae, which consitute an important element in the composition of the plankton of all the ponds examined. This can be clearly seen by following the distribution of these algae in pond Tayun A, Nir-David, where characteristic water-blooms developed in October, 1948, when the nitrogen content of the water was within the

limits found in natural waters and in the summer months of 1949 when the nitrogen content was unusually high (see Table III) following the administration of nitrogenous chemical fertilizers to the pond.

An interesting case of perennial blooming of Cyanophyceae is provided by the two ponds of Tel-Joseph (see Table XVII). The following are the possible explanations for this unusual phenomenon:

1. The fertilization of the ponds with cow and poultry manure in late fall.
2. The fertilization of the pond with cow urine in January and February, 1949.

The application of these organic fertilizers during fall and winter, might have accounted, at least in part, for the development of blue-green algal blooms at that time of the year.

Inorganic nitrogen was likewise found to be of little consequence for the development of Eugleninae and Cryptomonadinae. Such organisms developed, as a rule, towards the end of summer, when the water was richest in organic matter due to the decay of the blue-green algal masses.

The annihilating effect of ammonium salts on *Prymnesium parvum* has already been mentioned in the course of this paper (Reich and Aschner, 1946, 1947), but this must be considered a specific relationship which does not apply to Chrysomonadinae as a whole.

Phosphorus

Soluble phosphorus is found in minute quantities in the water sources of our fish ponds, its concentration generally not exceeding 0.04—0.05 mg/l PO_4. In the ponds, however, the phosphates were often found in higher concentrations as a result of the application of various types of phosphoruos fertilizers.

In both ponds of Nir-David, extensive use was made of superphosphate. As a result of this procedure, the phosphate content of these ponds was relatively high.

The two ponds of Tel-Joseph received no chemical fertilizer whatever. Organic fertilizers in the form of cow and poultry manure were the only fertilizers added to the ponds, having been administered in fall, a short time before this investigation began. The phosphorus content of the water remained, therefore, at a low level during fall and winter, and began to increase in spring and summer. It would be interesting to determine precisely what factors accounted for this rise in the phosphate content of the water in pond B during the spring and summer of 1949, when no fertilizers containing this constituent were administered to the pond. A plausible explanation might be that the organic manures added to the pond in fall, 1948, and winter, 1949, underwent a slow process of disintegration and mineralization, their effect beginning to be felt only with the rise in the phosphate concentration of the water in the early spring. The addition of these fertilizers favoured the development of filamentous blue-green algae—Hormogonales—during the winter months, while in the summer months the Chroococcales appeared as water-blooms, as stated above (see Table XVII).

As a result of conflicting evidence no clear relationship could be established between the fluctuations in the phosphate concentration of the water and diatom abundance. In some cases, the phosphates, together with the nitrates and silica, became exhausted when the winter and summer maxima of the diatoms were reached. This suggests that phosphorus, too, is likely to become a limiting element in diatom growth. In

other cases, however, no noticeable change took place in the phosphate concentration while the diatoms were at the peak. In pond 70 A, it was found that the phosphate content was at its lowest during the diatom peaks (see Table VI and Figure 4). However, the frequent additions of superphosphate to the pond prevented a complete examination of the effect of each application of fertilizer on the plankton flora.

The examination of relevant data derived from other ponds (e.g. B of Tel-Joseph and 13 of Messiloth) indicates that phosphorus cannot be considered a limiting element in diatom periodicity, as these algae are able to subsist and multiply successfully in an environment deficient in this element at certain times of the year. It has, however, been observed that the highest concentrations of diatoms occurred when the phosphates were on the increase and it may therefore be inferred that P serves as a stimulating though not indispensable factor in the development and reproduction of diatoms (see Table XV).

The green algae occurring in the plankton of these ponds have been found to be far more sensitive than diatoms to fluctuations in the concentration of phosphorus in the water. Their growth, for instance, is generally stimulated by an increase in the phosphate concentration. *Scenedesmus quadricauda* has been found to be a typical example of an organism responding to this relationship. This can be clearly seen from the analysis of data relating to Tayun A, Nir-David. The lower limit for the optimal growth of this species is 0.02 mg/l PO_4, this being in agreement with Rodhe's classification (1948) of plankton algae according to their phosphorus requirements. According to this classification, *Scenedesmus quadricauda* belongs to the category of algae having the highest phosphorus requirements.

TABLE XXI

Data on variations in the abundance of Scenedesmus quadricauda in relation to monthly fluctuations in Tayun A.

	1948			1949						
	19.X	13.XI	28.XII	28.I	7.III	12.IV	1.VI	12.VII	15.VIII	13.IX
Phosphates	traces	0.05	traces	0.025	0.3	—	0.06	0.14	traces	0.5
Scenedesmus quadricauda	traces	1000	traces	1500	3750	8750	2500	5000	600	2500

Similar requirements for phosphorus are shown by other plankton algae of this class, among them *Coelastrum microporum*.

The same correlation between the development of green algae and the fluctuations in the concentrations of phosphates has been observed also in pond 12, Messiloth. During the months of October, 1948, July and September, 1949, when the phosphates in this pond were on the increase, the green algae showed a corresponding increase in abundance. A similar phenmenon was observed in the neighbouring pond, 13, of the same settlement.

The alga *Botryococcus braunii* of the Heterokontae shows a dependence on phosphates similar to its dependance on nitrate nitrogen. In June, 1949, this alga was found to reach a concentration of 60,000 organisms per litre at the same time as the phosphates had reached a high point of 0.18 mg/l (see Table XII). This fact confirms the results arrived at by Chu (1943), who examined experimentally the environmental requirements of this species.

The specific environmental requirements of blue-green algae for essential nutrients have already been referred to in the course of this discussion. It only remains to be pointed out that soluble phosphorus seems to have no direct effect on the development of blue-green algae, as very intense water-blooms have been found to occur also in cases where the water had a very low phosphate content. However, the fertilization of the pond with organic manure, particularly poultry manure, was found to stimulate greatly the growth and development of these algae. The blue-green algae, for example, reached a peak in their development in pond 12, Messiloth, during July, 1949, when the phosphate concentration did not exceed 0.04 mg/l. In the same month, however, the water was richest in organic matter as a result of the frequent applications of poultry manure to the pond. The blue-green algae depend mainly on organic matter for their development and to a lesser extent on the dissolved nitrogen and phosphorus nutrients.

Of the phytoflagellates, *Euglena granulata* reaches its peak at the end of summer, in September, when the water is richest in organic matter and the phosphates are very plentiful. This fact has been repeatedly noted in several of the fish ponds examined by us. It applies equally to *Cryptomonas erosa*, which appears in the plankton of the ponds at the same time of the year and under the same conditions.

Silicon

From the data collected in this investigation, it appears that silicon is assimilated directly by the diatoms during their seasonal peaks. During these peaks the silicon is heavily drawn upon, occasionally being fully exhausted.

This relationship has been generally observed in all the fish ponds under examination during the winter and summer months, when the maxima in diatom abundance is found to take place. During the spring and fall, on the other hand, when the diatoms are either on the decrease or disappear almost completely from the plankton, the silicon in the water is restored, partly as the result of the addition of fresh water containing this constituent to the pond and partly because of the dissolution of the diatom shells which sink to the pond bottom. There is no proof whatever that silicon is an essential or a limiting element in the development of the other groups of algae.

The hydrogen-ion concentration of the water (see Tables III, VI, IX, XII, XV, XX)

The hydrogen-ion concentration (expressed as pH values) was found to fluctuate between 6.1 in winter and 9 in summer.

These fluctuations indicate that this factor is directly related to the productivity of the water habitat, i.e. in summer, when the photosynthesis is stronger due to increased development of phytoplankton, the pH is also high. In winter, when the rate of photosynthesis decreases, the pH is low, since the amount of CO_2 resulting from respiration or the decomposition of organic matter exceeds the CO_2 used in photosynthesis (Wiebe, 1932).

The characteristic features of the phytoplankton in the ponds investigated

The results of the phytoplankton analyses which were carried out during the period of this investigation show the existence of important seasonal changes in its composition.

Some of these changes in composition were common to all the fish ponds, while other changes were characteristic of specific ponds. These changes are partly due to natural factors inherent in the environmental conditions of this region and partly to the intervention of man in his day to day management of the ponds.

The natural conditions of the region determine the groups of phytoplankton which are likely to develop in this area generally and also the seasonal fluctuations of these algae.

There are in this part of the Beisan Valley, for example, particularly favourable conditions for the development of diatoms and blue-green algae as well as unfavourable conditions for the development of algae belonging to Desmidiaceae and Peridinae which are far more common in the inland waters of other parts of the country. The three types of fish ponds situated near the settlements of Nir-David, Messiloth and Tel-Joseph differ from one another chiefly in respect of their degree of salinity. In the first type, the salinity of the water is highest, approximately 1000 mg/l, in the second, between 400—500 mg/l and in the third, between 250—300 mg/l chlorine in chlorides.

These differences in the degree of their salinity account largely for the predominance of diatoms in the phytoplankton of the ponds of the first type. In the second type we find a predominance of algae common to both the first and the last type, such as diatoms and a great variety of green algal species. In the ponds of the third type with a low salinity, the green algae are the most important element of the phytoplankton and the diatoms are only of secondary importance. However, the blue-green algae dominate the summer plankton of all the ponds irrespective of their degree of salinity.

We have already mentioned that the two peaks in diatom periodicity occur in the winter and summer months. This phenomenon is characteristic of the Beisan region and of the Jordan Valley in general, as in other parts of the country the peaks in diatom periodicity occur mainly in spring and autumn.

The two species of *Cyclotella*, *C. kuetzingiana* and *C. meneghiniana*, are probably the most common diatoms in the three types of fish ponds. The occurrence of *Chaetoceros muelleri* in the ponds of Nir-David indicates the dependence of this organism on a high degree of water salinity. In the same way the occurrence of *Amphiprora paludosa* is characteristic of the marshy nature of the pond bottom, as is the case in Tayun A, Nir-David, and pond 12, Messiloth. Benthonic diatoms were very frequently encountered in the plankton of shallow ponds. They rise to the upper layers of the water in such ponds as a result of the action of the winds and the concomitant movement of the water.

The blue-green algae develop mainly in summer producing intense water-blooms at this time. The composition of these water-blooms may change from month to month, when one species is replacing the other and assuming a predominant place in the plankton. Most of the summer water-blooms of blue-green algae are caused by Chroococcales, among them the most important organism being *Synechocystis aquatilis*. This is a unicellular alga which often occurs in enormous quantities, overshadowing all the other components ot the plankton (Komarovsky 1951).

Microcystis flos aquae is another bloom producing alga common to all the ponds examined in this investigation. *Microcystis aeruginosa*, another important species, appears only in the plankton of the Tel Joseph and Messiloth ponds, whose water

salinity does not exceed 500 mg/l Cl. There are also cases where the blue-green algae bloom in winter and in fact throughout the year. Such a case was presented by the ponds of Tel-Joseph, when the blue-green algae constituted a continuous chain of water-blooms throughout the year (see Table XVII). In such cases it is interesting to note that in winter and spring the water-blooms are composed of filamentous blue-green algae, Hormogonales, and in summer of amorphous colonies of blue-green algae, Chroococcales.

The green algae found in the fish ponds occur mainly in summer. The number of the species of these algae, most of which belong to Protococcales, is larger in the Tel-Joseph and Messiloth ponds with their lower salinity, than in those of high salinity, such as Nir-David.

Some of these species, such as *Coelastrum microporum*, *Ankistrodesmus falcatus*, *Pediastrum duplex*, *Pediastrum boryanum* and *Scenedesmus quadricauda*, were found in all the fish ponds under observation.

Other species, however, are characteristic only of ponds with a low salinity, such as *Golenkinia radiata*, *Richteriella botryoides* and *Pediastrum simplex*.

As stated above, the green algae develop mainly in summer in so far as they are not suppressed by the blue-green water-blooms occurring at this season. There are, however, many cases of species of green algae which grow in considerable concentrations in winter and in spring.

Of the Conjugatophyta there are several species of Zygnemales which occur in all the ponds in spring especially during March and April, their occurrence being probably connected with the rainy season. These algae do not generally reach high concentrations in the plankton and their occurrence is most likely stimulated by the fertilization of the ponds with organic manure. This type of fertilizer, thanks to its slow decomposition, favours the development of filamentous algae (Swingle 1947).

The Desmidiaceae are only represented by a few species which occur in low numbers. The whole region is apparently unsuitable for the development of this group of algae.

CHRYSOMONADINAE. The Chrysomonadinae are chiefly represented by *Prymnesium parvum*, which reaches mass development in ponds with a salinity of over 500 mg/l Cl, its blooms often being toxic to fish. Mention has already been made of the use of ammonium sulphate as a means of controlling this harmful phytoflagellate (Reich and Aschner 1946, 1947). The main period of the development of this phytoflagellate is from mid-October to May (Komarovsky 1949), but blooms may occasionally occur also during the summer. The summer blooms of *Prymnesium* are, however, less likely to turn toxic to fish.

Wyssotzkia sp. is another Chrysomonad phytoflagellate which occurs in the fish ponds of this region. Its main period of development occurs in summer and it has never been known to turn toxic to fish. The phytogeographical distribution of this organism coincides with that of *Prymnesium*.

Of the Eugleninae most notable is the occurrence of *Euglena granulata*, which appears in very high concentrations at the end of summer, August and September, in all the ponds under investigation.

The Peridineae are represented in the plankton of the fish ponds by two species of *Glenodinium* only. These are found in the ponds of lower salinity, Tel-Joseph and Messiloth. Their occurrence in the spring plankton here coincides with that of other

phytoflagellates belonging to this group in the fish ponds of the Jordan Valley and Lake Tiberias, where, however, they reach much higher concentrations.

Most of the species recorded in this investigation have been mentioned in Rayss' paper on the blue-green algae (1938), in her book on the algae of fish ponds (1948), and in her recent paper on the algae of the inland waters of this country (1951).

The effect of fertilization

The administration of fertilizer to the ponds influences considerably the chemical and biological processes taking place in them and stimulates the development of plankton algae which are the basis of the food cycle in all types of natural waters. Organic and chemical fertilizers differ widely in their effects. The effect of the first is felt much later—one or two or even three months later—, owing to its slow decomposition in the water. It is, however, more stable in its effect and those ponds which were fertilized with organic manure only show less severe fluctuations in the concentration of the main dissolved nutrient salts. Organic fertilizer, in the form of cow and poultry manure, serves as a source of both nitrogen and phosphorus for the pond. The fertilization of the ponds with cow urine, as is practiced in Tel Joseph enriches the water primarily with ammonia nitrogen.

The effect of organic fertilizers on the phytoplankton is generally beneficial. Care should, however, be taken to administer them to the ponds towards the winter and spring, when there is no immediate danger of unlimited development of blue-green algal blooms.

The chemical fertilizers, owing to their quick dissolution in the water, create a very suitable environment for the uniform growth and distribution of the plankton algae in the whole body of the water.

Let us consider the extensive use made of ammonium sulphate in some of the ponds. This fertilizer serves as a means of controlling the Prymnesium blooms in the ponds of high salinity. In spite of its influence in speedily controlling the harmful phytoflagellates, the duration of its action is very limited owing to the quick loss of ammonia, partly in the form of gas and partly as nitrates and nitrites into which it is converted through bacterial action. For this reason, after the application of ammonium sulphate, the concentration of ammonia nitrogen immediately increases greatly. After a number of successive applications of this fertilizer, the concentration may rise as high as 7 mg/l or even higher. However, a quick decline sets in in the concentration of ammonia nitrogen, when the application of the fertilizer is interrupted for a longer period, so that within a few days or a few weeks at the most, the original concentration of ammonia nitrogen in the water is restored.

The use of superphosphates as a chemical fertilizer was tried out in the two ponds of Nir-David and proved to be highly beneficial to phytoplankton development. It has already been mentioned that, soon after the application of superphosphates to the ponds, the phosphate concentration of the water increased considerably, stimulating thereby the development of several important groups of plankton algae.

As to the foodstuffs given to the fish, it should be mentioned that this factor has not been dealt with in this study, as it is felt that this should form the subject of a separate investigation.

It is deemed desirable that this investigation should be extended to other pond areas

and be supplemented by physiological experiments into the environmental requirements of some of the most important plankton algae found in this region. The combined results of both the ecological and physiological lines of research may contribute greatly towards an understanding of the problem, not only from a theoretical but also from a practical and economic point of view.

From a taxonomic and phytogeographical standpoint, the list of plankton algae presented in this paper should prove a contribution to the knowledge of the fresh-water flora of this part of the world.

GENERAL LIST OF PLANKTON ALGAE OCCURRING IN THE PONDS UNDER INVESTIGATION

	Nir	David	Mes-	siloth	Tel	Joseph
	Tayun A	70A	12	13	B	D
DIATOMEAE						
1. *Amphiprora ornata* Bailey	*					
2. *Amphiprora paludosa* W.Smith	*		*			
3. *Bacillaria paradoxa* Gmel.	*		*			
4. *Chaetoceros muelleri* Lemm.	*	*				
5. *Cyclotella comta* (Ehr.) Kuetz.					*	
6. *Cyclotella kuetzingiana* Thwait.	*	*	*	*	*	*
7. *Cyclotella meneghiniana* Kuetz.	*	*	*	*	*	
8. *Cymbella affinis* Kuetz.	*					*
9. *Diatoma vulgare* Bory					*	
10. *Gomphonema astigmatica* Cleve, *symetrica* Grunow	*	*				
11. *Gomphonema olivaceum* (Lyngb.) Kuetz.			*			
12. *Gyrosigma acuminatum* Kuetz.	*	*				
13. *Gyrosigma attenuatum* Kuetz.					*	
14. *Gyrosigma scalproides* Rabb.	*					
15. *Gyrosigma spencerii* (W.Smith) Cleve	*	*				
16. *Melosira* sp.		*				
17. *Meridion* sp.	*					
18. *Navicula* 120/25 μ			*			
19. *Navicula* sp.100/36 μ				*		
20. *Navicula* sp.100/25 μ		*				
21. *Navicula* sp 96/32-40 μ	*		*			
22. *Navicula* sp. 88/32 μ		*				
23. *Navicula* sp. 84/25 μ			*			
24. *Navicula* sp. 84/8 μ	*					
25. *Navicula* sp. 80/10 μ						*
26. *Navicula* sp. 68-72/8 μ		*	*		*	
27. *Navicula* sp. 64/12 μ						*
28. *Navicula* sp. 52/4 μ				*		
29. *Navicula* sp. 42/17 μ	*					
30. *Navicula* sp. 35/8 μ	*					
31. *Navicula* sp. 32/12 μ				*		
32. *Navicula* sp. 24-28/4-6 μ	*	*		*		*
33. *Navicula* sp. 20/4 μ						*
34. *Navicula* sp. 14/4 μ				*		
35. *Nitzschia sigma* Kuetz.	*	*		*	*	
36. *Odontidium anomalum* V.Smith				*		
37. *Pinnularia brevicostata* Cleve				*		
38. *Pinnularia* sp.	*					
39. *Rhoicosphenia curvata* (Kuetz.) Grun.	*					
40. *Stauroneis anceps* Ehrenb.	*	*		*	*	*
41. *Surirella ovalis* Breb.						*
42. *Surirella ovalis* v. *ovata* Kuetz.					*	
43. *Surirella saxonica* Auersw.				*		
44. *Surirella* sp.	*					
45. *Synedra ulna* Ehrenb.	*			*		*
CHLOROPHYCEAE						
Protococcales						
46. *Actinastrum hantzschii* Lagerh.	*	*		*	*	*
47. *Ankistrodesmus falcatus* (Corda) Ralfs						*
48. *Ankistrodesmus falcatus* v. *acicularis* (A.Br.) G.S.W.	*	*		*	*	
49. *Ankistrodesmus falc.* v. *duplex* (Kg) G.S.W.	*			*		*
50. *Ankistrodesmus falc.* v. *mirabile* W.&G.S.W.	*	*		*	*	*
51. *Ankistrodesmus falc.* v. *spirilliformis* W.S.West				*	*	
52. *Ankistrodesmus lacustris* (Chodat) Ostenf.						*
53. *Ankistrodesmus longissimus* (Lemm.) Wille					*	*
54. *Characium debaryanum* (Reinsch) De Toni	*	*		*	*	*

		Nir David Tayun	A	70A	Mes-siloth 12	13	Tel Joseph B	D
55.	*Characium* sp.							*
56.	*Coelastrum microporum* Naegeli	*	*	*	*	*		
57.	*Crucigenia tetrapedia* (Kirchner) W.&G.S.W.	■			*	■		
58.	*Dictyosphaerium pulchellum* Wood				*	*	*	
59.	*Dictyosphaerium* sp.			*				
60.	*Gloeocystis vesiculosa* Naegeli				*			
61.	*Golenkinia radiata* Chod.				*	*	*	*
62.	*Kirchneriella lunaris* (Kirchner) Moeb.	*			*	*	*	
63.	*Kirchneriella obesa* (W.West) Schmidle							*
64.	*Kirchneriella subsolitaria* G.S.West				*			
65.	*Lagerheimia longiseta* (Lemm.) Printz					*		
66.	*Oocystis gigas* v. borgei Lemm.	*	*	*	*	*	*	
67.	*Palmellococcus* sp.		*		*	*		
68.	*Pediastrum boryanum* (Turpin) Menegh.	*	*		*	*	*	
69.	*Pediastrum clathratum* (Schroeter) Lemm.						*	
70.	*Pediastrum duplex* Meyen	*	*	*	*	*	*	
71.	*Pediastrum ovatum* (Ehrbg.) A.Br.						*	
72.	*Pediastrum simplex* (Meyen) Lemm.						*	*
73.	*Pediastrum sturmii* Reinsch						*	
74.	*Planktosphaeria gelatinosa* Smith					*		
75.	*Richteriella botryoides* (Schmidle) Lemm.	*	*	*	*	*	*	
76.	*Scenedesmus acuminatus* (Lag.) Chod.	*	*	*	*	*	*	
77.	*Scenedesmus arcuatus* Lemm.	*	*				*	
78.	*Scenedesmus acutiformis* Schroed.			*				
79.	*Scenedesmus bijugatus* v. *alternans* (Reinsch) Kuetz.	*	*					
80.	*Scenedesmus longus* (Meyen)				*			
81.	*Scenedesmus obliquus* (Turp.) Kuetz.	*	*	*	*			
82.	*Scenedesmus quadricauda* (Turp.) Bréb.	*	*	*	*	*	*	
83.	*Scenedesmus quadricauda* v. *dispar* Bréb.	*	*	*	*			
84.	*Sphaerocystis schroeteri* Chod.				*			
85.	*Tetraëdron minimum* (A.Br.) Hansg.	*			*	*		
86.	*Tetraëdron muticum* (A.Br.) Hansg.	*			*	*	*	
87.	*Tetraëdron* Sect. *Pseudostraurastrum*					*	*	
Volvocales								
88.	*Chlamydomonas* sp.	*						
89.	*Eudorina elegans* Ehrenb.				*			
Ulotrichales								
90.	*Microspora stagnorum* (Kuetz.) Lagerh.				*			
CONJUGATOPHYTA								
91.	*Closterium* sp.	*			*		*	*
92.	*Cosmarium* sp.					*		
93.	*Mougeotia* sp.	*			*		*	*
94.	*Spirogyra* sp.	*			*			*
95.	*Zygnema* sp.							*
CYANOPHYCEAE								
96.	*Anabaena* sp.	*			*	*	*	*
97.	*Anabaena oscillarioides* v. *cylindracea* Playfair	■						
98.	*Anabaena spiroides* Klebahn						*	
99.	*Anabaenopsis arnoldii* Aptekarj							*
100.	*Anabaenopsis circularis* (G.S.West) V. Miller				*	*	*	*
101.	*Anabaenopsis elenkini* V. Miller				*			
102.	*Aphanocapsa endophytica* G.M.Smith (within colonial envelope of Microcystis)						*	
103.	*Aphanocapsa pulchra* (Kuetz.) Rabenh.	*	*	■	*	*	*	
104.	*Aphanocapsa rivularis* (Carm.) Rabenh.						*	
105.	*Aphanothece microscopica* Naegeli						*	
106.	*Aphanothece saxicola* Naegeli							*
107.	*Aphanothece* sp.					*		
108.	*Chroococcus minutus* (Kuetz.) Naegeli	*	*	*	*	*	*	
109.	*Dactylococcopsis africana* G.S.West	*	*					
110.	*Gloeocapsa granosa* (Berkeley) Kuetz.							*
111.	*Holopedia dicteli* (Richter) Mig.	*	*	*	*	*	*	
112.	*Lyngbia cryptovaginata* Schkorbatow						*	

	Nir David Tayun	Mes-siloth A			Tel Joseph B		Nir David Tayun	Mes-siloth A			Tel Joseph B	
113. *Microcystis aeruginosa* Kuetz.			*	*	*	*	131. *Euglena gracilis* Klebs	*				
114. *Microcystis firma* Rabenh.						*	132. *Euglena oxyuris* Schm. f. minor Defl.	*	*			
115. *Microcystis flos aquae* (Wittrock) Kirchner	*	*	*	*	*	*	133. *Euglena proxima* Dang.				*	
116. *Microcystis marginata* (Meneghini) Kuetz.					*		134. *Euglena* sp.		*		*	*
117. *Oscillatoria annae* van Goor			*	*			135. *I epocinclis teres* (Schmitz) Francé				*	
118. *Oscillatoria chlorina* Kuetz.					*		136. *Phacus* anacoelus Stokes	*		*		
119. *Oscillatoria chlorina* v. *perchlorina* Lauterhorn	*						138. *Phacus pyrum* (Ehrenb.) Stein	*	*	*	*	
120. *Oscillatoria formosa* Bory	*	*	*	*		*	139. *Phacus* sp.				*	
121. *Oscillatoria mougeotii* Kuetz.						*	PERIDINEAE					
122. *Oscillatoria simplicissima* Gomont			*				140. *Glenodinium cinctum* Ehrenb.				*	
123. *Oscillatoria* sp.	*				*		141. *Glenodinium neglectum* Schiller			*		* *
124. *Oscillatoria* sp. (2 μ diameter)			*				HETEROKONTAE					
125. *Phormidium molle* (Kuetz.)				*	*	*	142. *Botryococcus braunii* Kuetz.				*	*
126. *Spirulina major* Kuetz.		*	*	*			143. *Chlorobotrys regularis* (West) Bohlin			*	*	
127. *Spirulina platensis* (Nordst.) Geitler	*	*	*	*	*	*	CRYPTOMONADINAE					
128. *Synchocystis aquatilis* Sauvageau	*	*	*	*	*	*	144. *Cryptomonas erosa* Stein	*	*	*	*	* *
EUGLENINAE							CHRYSOMONADINAE					
129. *Euglena ehrenbergii* Klebs	*	*	*				145. *Prymnesium parvum* Carter	*	*		*	
130. *Euglena granulata* (Klebs) Lemm.	*	*	*				146. *Wyssotzkia* sp.	*	*		*	

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SUR QUELQUES CHAETOGNATHES D'ISRAEL

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RESUME: Un lot de 158 *Sagitta*, immatures pour la plupart, récoltées le long de la côte d'Israël, a fourni les cinq espèces suivantes: *S. friderici* R.-Z., *S. bipunctata* Q. et G., *S. enflata* Gr., *S. minima* Gr., *S. serrato-dentata* Krohn (=*S. serratodentata atlantica* T.).

Parmi ces espèces, il en est deux qui attirent des remarques particulieres: *S. friderici* R.-Z. n'avait encore jamais été signalée en Méditerranée. *S. serrato-dentata* K. (=*S. s. atlantica* Tokioka), forme très halophile, se rencontre seule, aussi bien, dans le Bassin oriental que dans le Bassin occidental de la Méditerranée, à l'exclusion de *S. serratodentata pacifica* Tokioka et *S. serratodentata tasmanica* Thomson, espèces voisines à crochets également serrulés.

Nous avons eu l'occasion d'examiner récemment un lot de Chaetognathes que nous a aimablement fait parvenir le Dr. B. Komarowsky de la "Sea Fisheries Research Station" d'Haifa, Israël.

Ces Chaetognathes proviennent de 12 stations de pêche réparties le long de la côte d'Israël (Figure 1) et dont les caractéristiques sont les suivantes:

N° des stations	*Nom des lignes de stations*	*Date*	*Profondeur*	*Température*	*Salinité*
1	Askalon	13— 8—51	45-Om	24,60	39,72
2	Askalon	21—11—51	15-Om	—	39,49
3	Nathania	14— 6—51	45-Om	21,61	39,11
4	Atlith	19— 6—51	125-Om	—	—
5	Nebi Yunis	12— 6—51	45-Om	21,20	38,86
6	Nebi Rubin	13— 6—51	15-Om	24,00	39,20
7	Atlith	31— 1—50	75-Om	18,10	39,00
8	Atlith	14— 4—50	75-Om	17,,20	39,07
9	Sidni Ali	25— 5—49	125-Om	1615	38,89
10	Nebi Rubin	13— 2—50	75-Om	16,70	39,00
11	Caesarea	24— 3—49	50-Om	15,65	38,89
12	Nathania	14—12—49	15-Om	20,80	39,02

Figure 1

Représentation schématique de la répartition sur les côtes d'Israël de cinq especes de Chaetognathes d'après douze stations de pêche.

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Cette collection comprend 158 *Sagitta* se rapportant à cinq espèces pour lesquelles nous donnons dans le tableau ci-après le détail des récoltes avec leur nombre respectif à chaque station et leur pourcentage total.

N° des stations	*Nombre de Sagitta par station*	*S.friderici* R.-Z.	*S.bipunctata* Q. *et* G.	*S.enflata* Grassi	*S.minima* Grassi	*S.serrato-dentata* Krohn
1	10	9	—	1	—	—
2	30	20 ?	10 ?	—	—	—
3	19	8 ?	1+8 ?	2	—	—
4	6	1	2	3	—	—
5	2	—	2	—	—	—
6	25	23	1	1	—	—
8	34	22	—	7	5	—
9	21	—	—	7	14	—
10	2	—	—	1	1	—
11	6	5	—	—	—	1
12	3	—	—	1	2	—
Total	158	88	24	23	22	1
%		55,9	15,0	14,5	14,0	0,6

(Les points d'interrogation concernent les spécimens dont la détermination n'a pu être faite avec certitude vu leur très petite taille ou leur mauvais état de conservation— La station 7 n'est pas indiquée dans cette liste, l'échantillon ayant été perdu au cours du voyage.)

I. MORPHOLOGIE

1°) Ces Chaetognathes, dans leur grande majorité, sont très jeunes, donc de petite taille. Sur 151 spécimens dont le stade de maturité sexuelle a pu être évalué, 101 sont au stade I, 38 sont au stade II, 12 sont au stade III.

En conséquence, certains caractères morphologiques propres aux adultes, tels que l'aspect des ovaires et des vésicules séminales, n'ont pu être utilisés pour la détermination de la plupart de ces individus.

2°) En ce qui concerne les autres caractères morphologiques, les données ci-dessous, obtenues d'après dix spécimens de chaque espèce (sauf pour *S. serrato-dentata* représentée par un unique exemplaire), concordent avec celles généralement fournies par les auteurs*.

	Longueur totale (mm)	*Segment caudal %*	*Crochets*	*Dents antérieures*	*Dents postérieures*	*Ovaires (mm)*
S. friderici	4,2—10,2	21,4—28,5	6—8	4—8	8—14	jusqu'à 1,5
S. enflata	3,5—15	15,3—22,8	9—10	5—6	6—10	jusqu'à 1
S. minima	3,8—6	18,1—25,4	7—8	4—6	7—9	jusqu'à 0.5
S. serrato-dentata	10,5	24,7	5	4—5	12—13	1,7 (stade II)

* — Il ne figure pas de données pour *S. bipunctata* dont les échantillons, quoique déterminables, étaient trop abimés pour être étudiés en détail.

3°) L'unique exemplaire de *S. serratodentata* appartient à la forme *S. serratodentata atlantica* Tokioka caractérisée par l'existence de deux papilles au coin antéro-latéral des vésicules séminales.

Chez cette Sagitta de 10,5 mm, les papilles, bien visibles, ont leur pointe dirigée vers le bas, ce qui est caractéristique du stade II de maturité sexuelle, alors que, chez les individus pleinement adultes, ces organes sont redressés.

II. BIOLOGIE

1°) *Répartition des espèces récoltées*

— La répartition géographique de ces cinq espèces semble très homogène. En effet, à part *S. serratodentata atlantica* rencontrée en une seule station, les autres espèces se retrouvent en différents points de la côte de Palestine, comme le montre la figure 1.

— La répartition saisonnière ne peut être fixée avec certitude car les prélèvements examinés sont trop peu nombreux, bien qu'ils aient porté sur les quatre saisons de l'année.

Cependant *S. friderici*, *S. minima*, *S. enflata* sont présentes en toutes saisons, tandis que *S. bipunctata* n'a été recueillie qu'au printemps et *S. serratodentata atlantica* qu'en hiver.

— La répartition bathymétrique s'établit ainsi:

Niveaux	15-*Om*	45-*Om*	75-*Om*	125-*Om*
Nombre de pêches	3	4	2	2
S. friderici	43	22	22	1
S. enflata	2	3	8	10
S. minima	2	0	6	14
S. bipunctata	11	11	0	2
S. serratodentata	0	1	0	0

Les quatres espèces, *S. friderici*, *S. enflata*, *S. minima*, *S. bipunctata*, qui sont considérées comme épiplanctoniques, sont précisément bien représentées. La rareté de *S. serrato-dentata* s'explique par le fait qu'en Méditerranée elle se tient généralement dans des couches plus profondes. (Faure, 1952),

2°) *Remarques biogéographiques*

— *S. bipunctata*, *S. enflata*, *S. minima* sont communes en Méditerranée et leur présence sur les côtes d'Israël n'attire aucun commentaire particulier.

Celle de *S. friderici* et de *S. serrato-dentata* mérite qu'on s'y arrête. — *S. friderici* Ritter-Zahony, en effet, abondante dans la partie africaine de l'Atlantique (Faure 1952), n'avait jamais été signalée en Méditerranée. Nous n'en avons pas observé une seule dans les récoltes du "Président-Théodore-Tissier" (1950) en Méditerranée occidentale.

Ce n'est donc pas sans une certaine surprise que nous l'avons retrouvée dans le Bassin oriental.

Son existence dans cette partie de la Méditerranée demanderait d'ailleurs à être contrôlée car, répétons-le, le matériel que nous avons étudié se compose en grande majorité d'individus très jeunes, de détermination malaisée, pouvant parfois prêter à confusion avec des espèces voisines. L'examen de spécimens plus âgés permettrait sans doute de régler la question.

— *S. serrato-dentata* Krohn

Pour cette espèce, que nous nous proposons d'ailleurs de réviser très prochainement, rappelons qu'il existe trois formes:

l'une, *S. s. pacifica* Tokioka, est vraisemblablement localisée au secteur australien d'où on l'a décrite,

la deuxième, *S. s. tasmanica* Thomson, de distribution beaucoup plus large, peuple non seulement le Pacifique australien mais encore la partie nord de l'Atlantique oriental,

la dernière, enfin, *S. s. atlantica* Tokioka, est aussi présente dans l'Atlantique (côtes marocaines par exemple) mais, en raison d'une halophilie très accentuée, son domaine de prédilection est la Méditerranée.

Nous avons pu vérifier son existence en Méditerranée occidentale à l'exclusion des deux autres formes et démontrer qu'elle y atteint un développement supérieur à celui qui est le sien dans des régions de salure plus basse.

Ceci nous avait amenée à supposer qu'elle devait se rencontrer seule également dans le Bassin oriental de la Méditerranée. L'observation sur les côtes d'Israël d'un exemplaire se rapportant précisément à cette forme confirme donc notre hypothèse.

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A STUDY OF NUTRITION HABITS UNDER RATIONING CONDITIONS IN ISRAEL

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SUMMARY: 1) All food consumed under rationing conditions by a family of four was weighed and analyzed for protein, fat and carbohydrate content during one month; 2) A pronounced appetite for eggs was shown by all family members and satisfied by the supplementation of the ration by eggs *ad libitum*; 3) Supplementing of eggs was proved to be unnecessary, since the unsupplemented ration was complete with respect to protein and amino acids; 4) Caloric intake was low, owing to inadequate cooking and eating habits thus causing an abnormal high desire for proteins, which subsided when larger quantities of carbohydrates were eaten.

When a population formerly accustomed to unrestricted nutrition conditions allowing the free choice of foodstuffs is subjected to food rationing, many eating and cooking habits have to be changed in order to adjust to the new conditions, a task which is not always adequately performed. Inadequate adjustment to rationing conditions can in many cases lead to incomplete use of a food ration which in itself provides all the necessary nutrients. Unbalanced food intake is thus caused and leads to undesirable nutritional and economical consequences. It seems therefore desirable to investigate the composition of food consumed under rationing conditions by people whose former nutrition habits differed widely from those imposed by rationing and to assess whether they could successfully adjust to the new conditions.

Work of this kind must of necessity take into account individual variations in eating and cooking habits, and therefore precludes the use of statistical survey methods, which, while giving a fairly accurate picture of the "overall" nutrition situation, tend to abolish individual differences.

The results presented in this paper which deal with the food intake of a single family during 3—4 weeks cannot, of course, be taken as statistically representative or significant, they significantly illustrate, however, certain problems of nutritional adjustment common to a large part of the population in Israel.

METHODS

The main difference between former unrestricted nutrition and present rationing in Israel lies in the severe restrictions imposed on meat, egg and potato consumption. These foods are largely replaced by fish, cheese and such carbohydrate-containing foods as sweet potatoes, noodles and the like.

A family was therefore chosen for this survey whose food formerly contained comparatively large quantities of meat, eggs and potatoes, as did the food eaten by most

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families of European (Continental) origin. The senior author's family was chosen because it offered the best conditions for accurate observations.

The family whose food was examined, consisted of four persons:

1) Hanan M., Chemist (age 41, weight 62 kg, height 170 cm); Country of origin: Germany.
2) Raya M., Housewife (age 38, weight 52 kg, height 156 cm); Country of origin: Poland.
3) Raanan M., their son (age 6, weight 22 kg, height 112.5 cm); Country of origin: Israel.
4) Ofra M., their daughter (age $2\frac{1}{2}$, weight 15 kg, height 88 cm); Country of origin: Israel.

During the experimental period of four weeks (3 weeks in the case of the children) the egg ration officially distributed was 4 eggs per week, fish fillet, carp and sole was rationed and available in fairly large quantities and milk and white cheese were unrationed. No meat was distributed during the experimental period.

Existing eating and cooking habits were in no way experimentally changed. Three main meals per day were the rule, with dinner at noon. Additional food was eaten whenever appetite was felt.

It appeared that the need for additional eggs was felt most strongly by all members of the family, fried and scrambled eggs being preferred to cooked ones. Eggs were therefore provided *ad libitum*. Care was taken, however, that no available fish and milk proteins were replaced by egg protein; additional eggs were therefore allowed only after all the regular meals were eaten. This procedure was instituted in order to test how much additional proteins were required for complete satisfaction of appetite and whether they were used to complete an inadequate ration or eaten to make the ration as much as possible conform to existing nutrition habits.

Analytical methods

All food consumed was accurately (to 0.1 g) weighed, and uneaten food was weighed and subtracted. Suitable samples were taken and analyzed.

Dry matter was determined by blending the sample with 20 times its weight of acetone in a Waring blendor, decanting, repeating the procedure twice, filtering and drying the residue at room temperature and then for 15 minutes at 75°. This procedure resulted in perfectly uniform samples which showed no signs of caramelization or other signs of decomposition sometimes encountered when samples are heated to 105° for prolonged periods. The results were corrected for the residual 3—4% adsorbed water-dry by drying a separate small sample at 105° to constancy and to the fat dissolved by the acetone treatment, which was determined by evaporating the acetone used for drying the sample, extracting the fat from the remaining water with ether, evaporating the ether and drying and weighing the residue. Total fat was determined by extracting a weighed aliquot of the sample with ether, drying and weighing the ether-soluble material and adding the value (calculated on the whole sample) to the acetone extract to form the total fat percentage.

Carbohydrates were calculated as glucose liberated by hydrolyzing a 0.5 g sample for 1½ hours with 2% HCl in a boiling water bath.

Protein was determined by the conventional Kjeldahl method (N × 6.25). (N × 6.38 for milk proteins).

Foods which were eaten unchanged by cooking or otherwise processing them, and the composition of which tends to be fairly constant like bread, milk and the like, were not analyzed as individual samples. Small samples of these foods taken daily and pooled to form a single average sample for the whole experimental period, were analyzed and the results used for calculations. All cooked or otherwise prepared or mixed foods were analyzed individually.

Analyses for vitamins or minerals were not carried out, with the exception of vitamin A and carotene values, which were reported elsewhere (Meyer and Mirzon 1952).

Owing to the large number of analytical results, no individual values are contained in the following tables. It seems, however, indicated to report here some conclusions drawn from the analytical results.

1) The composition of raw foods found by us did not differ significantly from the values appearing in internationally accepted food tables (McCance and Widdowson 1947).

2) Cooked foods, especially those composed of a number of different foodstuffs, like soups, varied considerably with regard to their dry matter content. This fact should carefully be taken into account, when determining the food value of rations by mere weighing. It was, however, observed that, owing to the fixed cooking habits of the individual housewife, dry matter contents of one and the same dish prepared several times during the experimental period, varied only insignificantly.

3) The conclusion is therefore drawn for future work, that a single determination of dry matter and its chemical composition of each food can be used during prolonged experimental periods.

The following tables contain the results obtained during the experimental period of 28 days for Hanan and Raya M., 23 days for Raanan M. and 22 days for Ofra M.

It will be noted that two sets of results have been tabulated, one for the food actually consumed and the other for the food which had been eaten would only the official egg rations have been consumed. As mentioned before protein intake was not restricted, but an *ad libitum* level was allowed to form by supplementing the official ration with eggs. The known amounts of egg protein eaten over and above the official ration of 4 eggs per week (and of the fat used for frying or scrambling the eggs) were therefore subtracted from the total food eaten (Table I) and the values so obtained were tabulated separately. (Table III and all the numbers given in parentheses in Tables IV and V).

TABLE I

Food eaten (grams)

	Hanan	*Raya*	*Raanan*	*Ofra*
Dry matter	13653.2	8888.0	6892.0	3884.8
Carbohydrates	9115.0	6083.2	4108.9	2516.6
Proteins	2210.6	1445.7	1286.0	695.7
Fats	1937.6	1095.7	899.3	643.1

TABLE II

Average daily intake of nutrients (actually eaten) in grams per day

	Hanan	*Raya*	*Raanan*	*Ofra*
Carbohydrates	325.6	217.3	178.8	114.4
Proteins	79.0	51.6	55.2	31.6
Fats	70.2	39.1	39.2	29.3
Calories	2307	1457	1270	868
Ratio of proteins to carbohydrates	1:4.1	1:4.2	1:3.25	1:3.6

TABLE III

Average daily intake of nutrients (corrected to official rations) in grams per day.

	Hanan	*Raya*	*Raanan*	*Ofra*
Carbohydrates	325.6	217.3	178.7	114.4
Proteins	70.4	50.0	50.8	28.8
Fats	61.6	38.2	33.1	27.4
Calories	2192	1447	1215	840

TABLE IV

Composition of the protein contained in the actual and corrected rations

		Hanan	*Raya*	*Raanan*	*Ofra*
The protein part of the ration contains protein from:	Eggs	18.0 (8.5)	11.7 (8.8)	22.0 (13.5)	20.4 (14.8)
	Milk	9.1 (10.1)	17.9 (18.6)	31.5 (35.0)	39.4 (42.0)
(in percent of the total protein)	Fish	13.3 (14.7)	13.9 (14.4)	12.8 (14.2)	10.5 (12.3)
	Bread	33.0 (26.3)	35.6 (36.8)	18.4 (20.4)	22.0 (23.6)
	Other sources	26.6 (30.4)	20.9 (21.4)	15.3 (16.9)	7.7 (8.3)
Total Animal Protein		40.4 (33.3)	43.5 (42.8)	66.3 (62.7)	70.3 (68.1)

TABLE V

Daily average intake of essential amino acids (compared with the experimentally established requirement values from the literature) in grams per day

	Hanan	*Raya*	*Raanan*	*Ofra*	(*Rose*, 1950)*
Tryptophan	0.75(0.62)	0.54(0.52)	0.67(0.54)	0.41(0.38)	0.25—0.5
Lysine	3.3 (2.7)	2.3 (2.2)	3.5 (3.2)	2.0 (1.9)	0.8 —1.6
Phenylalanine	3.1 (2.7)	2.1 (1.9)	2.6 (2.3)	1.6 (1.5)	1.1 —2.2
Leucine	5.0 (4.2)	3.5 (3.4)	4.5 (4.0)	2.8 (2.6)	1.1 —2.2
Isoleucine	3.3 (2.7)	2.4 (2.2)	3.2 (2.7)	1.9 (1.8)	0.7 —1.4
Threonine	2.3 (1.9)	1.9 (1.8)	2.0 (1.8)	1.4 (1.3)	0.5 —1.0
Methionine	1.8 (1.5)	1.3 (1.2)	1.6 (1.4)	0.93(0.85)	1.1 —2.2
Valine	3.3 (2.8)	2.3 (2.2)	3.0 (2.6)	1.8 (1.7)	0.8 —1.6

* Daily need for adults (70 kg body weight).

DISCUSSION

The protein ration

It appears from the results given in Tables II and III that the total daily protein ration was not significantly enlarged by supplementing it with eggs, although during the course of the experiment all members of the family regarded the supplement as especially important and valuable. The total daily protein intake was increased by 12.3—2.4—8.7 and 10.1% for Hanan, Raja, Raanan and Ofra respectively. The percentage of supplemented egg protein differed but little except in the case of the housewife who did not supplement her ration to any appreciable extent, although her relative intake is the lowest in the whole family. It should be noted ,however, that all the supplemented protein is of high value and improves the ration more than its numerical percentage expresses. The question whether the protein ration needed improvement can be answered only by comparing the total and corrected rations with the values generally accepted as desirable.

The average protein content values of the rations after deducting the supplement correspond in the case of both adults to the value of 1 g protein per kg body weight per day often recommended (Winton and Bayliss 1949). The amounts eaten by the children are, too, well inside the recommended limits of 15—45 g per day for children up to 5 years and 40—60 g per children up to 12 years. The percentage of animal protein eaten by the children equals or exceeds that eaten in the meat eating countries (Australia 69%, U.S.A. 57%) although the adults get rather less (33—42.8%). All rations, however, contain incomparably more animal protein than those eaten in Asiatic countries (China 8.5%; India 16%) (Albanese 1959).

Further information with regard to the adequacy of the protein ration is obtained by calculating the amino acid content of the proteins ingested. The amino acid values appearing in Table V were calculated according to the newest and best analytical results available as given by Block and Bolling (1951). It is a well-known fact that despite the enormous amount of research work done in this direction the amino acid requirements for humans are still far from being accurately known. Rose's classical work (1950) has led to values that are given for comparison in Table V; they are now fairly generally accepted in the literature as adequate (Albanese 1950). Table V shows clearly that abundant quantities of amino acids are provided by the ration, even when taking into account only the corrected (lower) values. The children's amino acid intake was in all cases well above the largest amount claimed to be necessary by Rose for adults.

It can therefore be safely concluded that the protein ration is complete with respect to all the essential amino acids and contains enough additional nitrogen to cover fully all the nitrogen needed for the synthesis of the non-essential aminoacids and other nitrogen containing compounds.

The conclusion therefore offers itself that the protein supplement given in the form of eggs was not eaten for completing an insufficient protein ration but served other purposes, especially that of producing tastier meals.

The total protein percentage in the ration was fairly constant for both adults (15.4 and 16.4%) on one hand and for the children (19.3 and 17.4%) on the other hand.

It appears, however, that the adults and the children got their protein from totally different sources. The adults got almost one third of their protein from bread (Table IV) almost double the percentage derived from it by the children, who used milk and milk products as main protein source. Here again the percentage of egg protein was fairly constant (18–20.4%) except in the case of the housewife where it amounted to approximately one half of the amount eaten by the other family members. Fish proteins were the only ones eaten by all members of the family to the same extent. There appear therefore in a single family all the major nutrition trends prevailing in the population.

1) The family head is accustomed to eating concentrated high value proteins and therefore supplemented his ration most liberally with eggs. He is the only member of the family who ate larger vegetable rations which led to the large percentage of 26.6% vegetable protein in his ration. He uses milk and milk products only to a very limited extent.

2) The housewife derives her protein equally from all sources. Her protein supplement was the lowest of all.

3) The children's eating habits are clearly influenced by the good palatability of milk products. It should not be overlooked that the feeding of milk takes the least time and was resorted to frequently by the mother when other foods were eaten by the children only with difficulty.

4) The very low percentage of vegetable protein eaten by the smallest child points to a common problem in child nutrition, e.g. that many small children can only with difficulty brought to eat vegetables. This factor does in this case not influence the protein nutrition although it is liable to lead to difficulties with regard to minerals and vitamins.

The caloric value of the ration

Tables II and III show that the caloric value of all four rations is low, especially in the case of Raya M. This fact cannot be due to the lack of food of high fuel value, since bread was freely available and a sufficient ration of flour, fats, noodles and sugar was distributed. The ratio carbohydrate: protein in all four rations is indeed considerably lower (1:4.1 to 1:3.25) than the generally recommened value of 1:5. In the cases reported apparently insufficient use has been made of carbohydrates, thus reducing the fuel value of the ration. Stress was laid instinctively by all members of the family to eat as much protein as possible and in concentrated form; since the taste appeal of those foods is higher than that of the plain carbohydrate carrying foods. This is especially true in the case of the children where the carbohydrate intake is exceedingly low. They ate only small quantities of bread and could only with difficulty be induced to eat the more bulky cooked carbohydrates, like rice or noodles. It appears necessary to make a conscious effort to eat more carbohydrates, expecially bread (it was done in the present case after the experimental results became known) and to stimulate carbohydrate intake by suitably and attractively cooked meals. Since it is well known that carbohydrate consumption leads to a better nitrogen retention, (McCance and Widowson 1947) and vice versa protein is insufficiently utilized at low caloric and carbohydrate levels, being used as a fuel and thus upsetting the nitrogen equilibrium, the pronounced appetite for protein of all four subjects can

be explained by assuming that the low caloric intake did not allow an adequate utilization of the protein ration given. This assumption was indeed proved during later experiments (Meyer, unpublished) where it was shown that the appetite for additional protein promptly subsided when 500—1000 additional calories daily were eaten.

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STUDIES ON THE NEOGENE OF ISRAEL

I. A NEW PLIOCENE OUTCROP IN THE CENTRAL COASTAL PLAIN OF ISRAEL

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SUMMARY: A new Neogene outcrop, S of Ramle, confirms former observations. It is concluded that the marine regime of Helvetian-Tortonian ended with faulting and volcanism, which created external and inner fault-basins. Pliocene, in Asti- and Plaisancian facies, has transgressed upon the present Coastal Plain and the adjoining depressions.

In the Central Coastal Plain a new outcrop of Pliocene sandstone was recently laid bare by building activities. This outcrop is situated 9 km south of Ramle, on the west side of the Jerusalem-Jaffa railway line, between Hulda in the East, and Ekron in the West. The Pliocene sandstone is covered there by one or two m of recent continental sands. The Pliocene itself is transgressive upon a white chalky limestone and silicified limestone with brownish elongated flint nodules, of Lower Eocene. The surface of the Eocene stratum is irregularly abraded, intensely perforated by *Lithodomus*, the shells of which are sometimes preserved. Together with these biogenic perforations, there are numerous mechanical perforations made by hard flint pebbles, which have been rolled upon the Eocene rocks by the abrasive waves of Pliocene sea.

So the base of Pliocene is marked by *Lithodomus*-perforations and pebble horizon. The pebbles are formed mainly of Campanian flint, but also of Eocene limestone. and are fairly well rounded, their diameter varying between several mm up to about 10 cm. Of course, the flint pebbles came from a greater distance, possibly from at least some 15 km, as there are no nearer outcrops of Campanian flint horizon, while the pebbles of Eocene limestone were taken from the rocks outcropping on the spot.

With them together there are pebbles of vesicular basalt, of few up to 10 cm in diameter, included in Pliocene sandstone. The basalt is very friable. Nearly twenty years ago I had the opportunity to confirm the ancient observation of Drake (1872) about a basalt outcrop near Gezer (Abu Shushe), only 5 km ENE from the present outcrop (Avnimelech 1935), and later discovered a small new outcrop in Wadi Malih, only one km north of the present point; unfortunately this last outcrop has now completely disappeared, partly through erosion, partly through being covered by wadi deposits of most recent years. The present discovery gives a renewed opportunity to discuss the age of the volcanism, which is evidenced by the pebbles.

Together with these base conglomerates occurs sporadically a calcareous breccia tightly cemented by hard, compact or friable sandstone with some flint pebbles in-between, evidencing slumping of Eocene limestone on steep beaches. In such a breccia I have found a specimen of a small Porifera colony, grown among the limestone frag-

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ments. The Porifera are recognizable only by their shape and badly preserved external features, the inside being filled with sandstone, so that no determination is possible. By their shape and size (they are 6—10 cm long and 2—3 cm broad) they appear to belong to *Silicispongiae*. It is worth while to note this, since up to now no Porifera have been observed in the Neogene of this country.

The sandstone is very rich in fossils, but there are only few which can exactly evidence the age of the formation. The list contains as follows:

Callista pedemontana Lmk var. *sulcata* For.
Callistotapes cf. *vetulus* (Bast.)
Cardita (*Glans*) *?intermedia* (Brocchi)
Glycimeris gr. *insubrica* (Brocchi)

Natica sp (*?Nevrita josephina* Risso)
Potamides ?basteroti (De Serr.)
Turritella sp.

Echinoidea spines

Fish tooth

Nonion boueana (d'Orb.)
Nonion cf. *N.granosum* (d'Orb.)
Rotalia (*Streblus*) *beccarii* L.
" " cf. *beccarii* L.
Elphidium gr. *crispum* L.
Elphidium sp.
Asterigerina planorbis (L.)
Globigerina bulloides d'Orb.
Cancris auriculus (Fichtel and Moll)
Cibicides spp.
Miliolidae var. spp.
Textularia sp.
Amphistegina ?lessonii d'Orb.—two fragments, possibly redeposited from Helvetian rocks.

Redeposited from Eocene:
Globigerinella micra (Cole)
Globorotalia spp.
Globorotalia gr. *crassata* (Cushman)
Globigerina triloculinoides Plumer
Globorotalia wilcoxensis Cushman and Ponton
Uvigerina (two spp.)

Redeposited from Upper Cretaceous:
Globigerinella aspera (Ehrenberg)
Gümbelina excolata Cushman

The autochtonous foraminiferal fauna is of general Neogene character. The Eocene foraminifera originate from the basis of the transgression, while the Upper Cretaceous

foraminifera derive of material imported from afar. The molluscan fauna are analogous with that quoted in my paper on Shephela (Avnimelech 1935), and it corroborates the conclusion as to the Lower Pliocene age of the stratum. It demonstrates—a fact which has been noted previously—that the volcanism of the Shephela region is of pre-Pliocene age. We are now able to define it more exactly.

In the whole country traces of volcanic rocks in Lower Tertiary deposits are not known. The rocks of Helvetian (Lower Vindobonian) age, scattered in relics in several spots in the west of the country, contain no fragments of volcanics, although they are often intimately connected with basalt outcrops. Such is for instance the situation near Yokneam, on the Haifa-Megiddo road, where relics of Helvetian *Madrepora*-bioherms are found side by side with basalt outcrops. The basalts are clearly connected with faulting which has caused the subsidence of elongated blocks at the foot of the present Carmel mountains (along the Haifa-Megiddo road), leaving only here and there on the slopes small fringing outcrops of the Helvetian rocks. So the volcanism must be younger than Helvetian, but older than the Lower Pliocene. Conclusively the age of the volcanic activity and also of the faulting, may be defined as of Tortonian (possibly Upper Tortonian) age, while the almost complete destruction of volcanic products, by erosion, occurred during the Pontian, well characterized everywhere by its fault-basins.

As a conclusion there is the following sequence of events, evidenced by the new Pliocene outcrops in addition to the facts known before:

HELVETIAN: transgression in the piedmont ("Shephela") regions of the country, represented by conglomeratic and sandy, crystallized limestone and well characterized by the *Madrepora* bioherms.

TORTONIAN: in the *Lower Tortonian*—continuation of marine regime in the piedmont zone, especially in the south (Beersheba region); later, in the *Upper Tortonian*, faulting and volcanism.

PONTIAN: filling up of the inner fault-basins (of the deepened old ones and of the newly formed) and strong erosion, resulting in almost complete destruction of Helvetian deposits and of volcanic products; this Pontian may be, at least partly, synchronical with the Lower Tortonian.

LOWER PLIOCENE: conglomerate and sandstone formation (Asti-facies) on the borders of piedmont (shore-zone), marly sediments under the Coastal Plain (Plaisancian facies), while the filling up of the lagunal and lacustral basins continues in the inner regions of the country.

ACKNOWLEDGEMENT

I wish to express my acknowledgement to my assistants: Mr. Z. Reiss, who has determined the foraminifera and Mrs. Vera Boskovitz, who has helped me examine the molluscan fauna.

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LETTERS TO THE EDITOR

The Editorial Board does not accept responsibility for the views expressed in the letters printed below

Saturated Steady Flow in Non-Homogeneous Media with Applications to Earth Embankments, Wells and Drains

Darcy law, when applied to saturated isotropic non-homogeneous media, combined with the equation of continuity, leads towards a partial differential potential equation, of the Poisson type. Neither conformal mapping nor the usual flownet method may be applicable. The introduction of hydraulic resistivity (impermeability), the inverse of the hydraulic conductivity (permeability) simplifies the computations.

In one-dimensional confined flow the pressure decreases horizontally or upwards. In descending flow it may increase or present maxima and minima, where resistivity attains its average value along the flowline. The maximum is pronounced where resistivity increases rapidly and the flowline flattens out. The minimum is pronounced where conductivity increases rapidly and the flowline steepens. This is confirmed by pore-pressure measurements, in earthfill zoned embarkments, and by the author's observations on asphalt lined ponds (formation of huge asphalt bubbles), on brine pans at the Dead Sea, and on sand dunes after rainfall. A cavitation phenomenon is foreseen and observed in the soil whenever a thin impervious layer overlies a thick permeable one.

Average resistivity, an important factor, is computed in several cases.

A formula is developed for a horizontal draining gallery or ditch and found to be identical with that for homogeneous soils with average resistivity. When two gallaries drain a uniform rainfall, the water table is no more elliptic. In radial unconfined flow to a well, the discharge obeys a formula different from Dupuit's formula which is used by Thiem, and the correction is determined.

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Some Comments on "A Possible Cross-Viscosity Effect in Air"[1]

In a recent issue of this Bulletin[1] Reiner suggests a possible cross-viscosity effect in air. The experiment in question is one in which a cylinder is observed to rotate in a very viscous fluid in such a manner that the liquid does not wet the cylinder. Reiner proposes to use results from the hydrodynamic theory of lubrication which describe the flow between two infinite platens, one inclined slightly to the other and moving over a thin film of interposed viscous fluid. He uses the velocity solution $v_x = Gy$, $v_y = v_z = 0$ and finds that the Reiner stress-strain rate law[2]

$$p_{rs} = F_o\ \delta_{rs} + F_1\ f_{rs} + F_2\ f_{r\alpha}\ f_{s\alpha}$$

which includes a cross-viscosity term, yields a stress gradient, $\frac{\delta p_{zz}}{\delta z} = -\frac{F_2\ G^2\ \alpha^3\ y^2}{h_o^3}$ if α is considered small compared to h_o (Here the platens are separated by a distance $h = h_o + \alpha z$ and $G = V/h$ where V is the uniform velocity of the platen inclined to the $x - z$ plane at slope α).

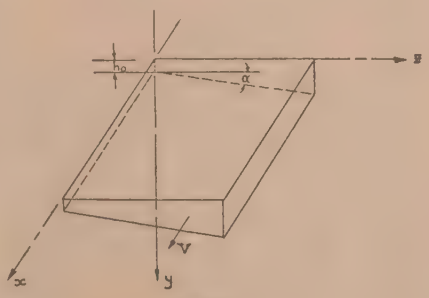

Figure 1

Reiner states that "an exact solution with *only* v_x different from zero complying with the above boundary conditions is not possible" for α not small. We have, however, been able to find a solution for any α which does satisfy the boundary conditions for the linear stress-strain relation and yields a cross-viscosity force. In the first place the linear, classical stress-strain rate relation leads to the Navier-Stokes flow equation whose complete form is

$$v_j \frac{\delta v_i}{\delta x_j} + \frac{1}{\varrho}\frac{\delta p}{\delta x_i} = \nu\, v_{i,jj}$$

where $i = 1,2,3$, v_i's are the velocity components, ϱ the density, ν the kinematic viscosity, and where the summation convention has been applied. For only v_x $(= v_1)$ different from zero, we

have immediately $\frac{\delta p}{\delta y} = 0$, $\frac{\delta p}{\delta z} = 0$ and

$$v_x \frac{\delta v_x}{\delta x} + \frac{\delta p}{\delta x} = \nu \left(\frac{\delta^2 v_x}{\delta x^2} + \frac{\delta^2 v_y}{\delta y^2} + \frac{\delta^2 v_z}{\delta z^2} \right).$$

But the present application is one in which the x-direction approximates the circumferential direction for the rotating cylinders. Therefore from the symmetry inherent in the cylindrical case we can infer that no quantity can depend on x. Thus we finally have

$$\frac{\delta^2 v_x}{\delta z^2} + \frac{\delta^2 v_x}{\delta y^2} = 0$$

The boundary conditions that Prof. Reiner has given are $v_x = V$, $y = h$; $v_x = 0$, $y = 0$; and $p_{zz} = 0$ at $z = \text{const}$. It is easy to show that $v_x = \frac{V}{h} y$ is a solution of the harmonic equation for α small.

On the other hand a solution for any α can be found easily by taking $y_1 = y/h$ and seeking a solution which is a function of y_1 only. The result is

$$v_x = C \tan^{-1} y_1 \alpha = C \tan^{-1} \frac{y\alpha}{h}$$

where $C = V/\tan^{-1}\alpha$ and where α can be any size (for $\alpha \to 0$, $v_x \to Vy/h$). This result for the classical, linear stress-strain rate law gives $p_{zz} = 0$ everywhere (providing p is taking to be zero at the boundaries; it is, of course, a constant throughout). But what is interesting is that $v_x = C \tan^{-1}(y\alpha/h)$ is also a solution for the Reiner stress-strain rate law; i.e. if we compute p_{rs} given by the Reiner expression and then apply the equilibrium condition $p_{rs,s} = 0$ (the inertia term, $v_x \frac{\delta v_x}{\delta x}$ is identically zero in our case) we find that the v_x given satisfies the equation. One must be careful, however, not to interpret the F_o in the Reiner expression as a hydrodynamic pressure: perhaps it is related but its nature requires further investigation.

An application of the above procedure provides

$$p_{zz} = F_o + F_2 \left[\frac{\frac{1}{4} C^2 y^2 \alpha^4}{(h^2 + y^2\alpha^2)^2} \right]; \quad F_o = \frac{-F_2 C^2 \alpha^2 \frac{1}{8}}{h^2 + y^2\alpha^2}$$

$$p_{zz} = F_2 \frac{C^2\alpha^2}{8} \left[\frac{\alpha^2 y^2 - h^2}{(\alpha^2 y^2 + h^2)^2} \right]$$

Although p_{zz} will be a function of y for any finite value of z, it can easily be shown that $p_{zz} \to 0$ as z becomes very large. Thus if we measure the generators of the rotating cylinder from $z = 0$, p_{zz} will approach zero as we approach the top of the cylinders, providing the height of the cylinder is very much greater than h_o This will be satisfied for h_o and α small enough, both of which seem to be a safe assumption from the point of view of the experiment.

It has thus been shown that a stress gradient exists in the z — direction. Proper choice of the sign for F_2 will insure this to be negative.

It might be interesting to point out that a three-dimensional treatment does not offer a transverse force of this nature if the classical, linear Stokes stress-strain rate relations are used. Suppose that we do not assume that v_y and v_z are identically equal to zero. Instead let us say that at $z = 0$, there exists a kind of barrier that will stop flow in the negative z direction ($v_z = 0$, $z = o$). We will then investigate to see if the total force on this barrier is also zero. If this is true then removing the barrier will still not allow flow in the z direction. We shall assume here that the inertia terms are small compared with the viscous terms. We have then the equations

$$\nabla^2 v_x = 0$$

$$\frac{1}{\varrho} \frac{\delta p}{\delta y} = \nu \nabla^2 v_y$$

$$\frac{1}{\varrho} \frac{\delta p}{\delta z} = \nu \nabla^2 v_z$$

$$\nabla^2 = \frac{\delta^2}{\delta y^2} + \frac{\delta^2}{\delta z^2}$$

Introducing a stream function Ψ such that $\Psi_y = v_z$, $\Psi_z = v_y$ we have

$$\nabla^2 v_x = 0$$

$$\nabla^4 \Psi = 0$$

with the boundary conditions

$$v_z = v_x = v_y = 0; \; y = h$$
$$v_z = v_y = 0; \; y = 0$$
$$v_x = V; \; y = 0$$
$$v_z = 0; \; z = 0$$

Observe that we have also altered the problem slightly by letting the inclined platen remain at rest, whereas previously it moved across the x—z plane at rest. This is only done for added ease in the computation and introduces no inherent change in the problem.

By introducing $z_1 = z/ho, y_1 = \frac{y}{h_o + \alpha z}$, a solution may be found by an iterative method, correct to 0 (α). We obtain

$$v_x = \sum_{m=o}^{\infty} A_{(2m+1)} \left\{ \sinh (2m+1)\pi\ (y_1 - 1)\ \sin (2m+1)\pi z_1 + \right.$$

$$\left. + \frac{\alpha(2m+1)\pi}{2} \left[y_1^2 - z_1^2 \right] \cos (2m+1)\pi z_1 \sinh (2m+1)\pi\ (y_1 - 1) \right\}$$

$$\Psi = \alpha \left\{ \sum_{n=1}^{\infty} \sin n\pi z_1\ (y_1 \sinh n\pi\ (y_1 - 1) + \dots \right.$$

$$\left. \dots + (y_1 - 1) \sinh n\pi y_1 + \frac{z_1 y_1}{2} (y_1 - 1) \right\}$$

where $A_m = \dfrac{4\ V\ (-1)^m}{m\pi \sinh (-m\pi)}$, $m = 1,3,5 \dots$;

$$B_n \quad \frac{(-1)^n}{n\pi\ (n\pi + \sinh(-n\pi))} \quad n \quad 1,2,3 \dots$$

The expansion for Ψ holds only for $-1 < z_1 < 1$ so that we can impose boundary condition along the positive z—direction only for $z < h_o$. This is no limitation since we are only interested in the condition at $z = 0$. From Ψ, v_z and v_y can easily be computed. It will be observed that only v_z is zero at $z = 0$, v_x and v_y having components of order α. Our barrier would apparently have to be of some special type of material.

From the velocity components, p can be computed and we obtain $p = -2\mu\alpha / h_o^3 \sum_{n\ o} B_n$ $n\pi \cos n\pi z_1\ (\sinh n\pi\ (y_1 - 1) + \sinh n\pi y_1) + C$. C is a function which may be evaluated by providing p at some value of z. Here μ is the viscosity and equals to $\varrho\nu$. Knowing p, and v_z, we may calculate p_{zz}.

$$p_{zz} = p + \mu f_{zz} = p + \mu \frac{\delta v_z}{\delta z}$$

$$= \frac{2\mu\alpha}{h_o^2} \left[\sum_{n=o}^{\infty} B_n \left\{ \cos n\pi z_1 \right.\right.$$

$$\left.\left. (n\pi\ g_n(y_1) + n\pi f_n \overset{1}{\vee} (y_1) \right\} + \tfrac{1}{2} (2y_1 - 1) \right]$$

where $g_n(y_1) = \sinh n\pi\ (y_1 - 1) + \sinh n\pi y_1$

$$f_n(y_1) = z_1 \sinh n\pi\ (y_1 - 1) + (z_1 - 1) \sinh n\pi y_1$$

The force in the negative z direction at $z = 0$ is then given by

$$F_{z\ 0} \int_o^h p_{zz}\ dy$$

and we find

$$F_{z\ o} \quad 0.$$

If we remove the barrier there will be no flow in the negative z direction.

We have shown that the Stokes stress-strain rate relation does not provide a transverse "pumping" effect in the case of two inclined platens sliding over a thin film. On the other hand, we have shown that such a force apparently does exist if the non-linear, Reiner law is used. It should be pointed out that in the use of the Reiner law, it was *not* assumed that inertia forces where negligible. For this case, when only v_x is assumed non-zero it happens coincidentally that inertia forces play no role. It might be interesting, however, to re-consider the problem as a three dimensional problem where the inertia forces are large and the viscous forces (and cross-viscosity forces) would be negligible. This is suggested by the fact that Prof. Reiner has noted that the non-wetting of the cylinder which he describes occurs only at high speeds of rotation. It would seem worthwhile to attempt to find a solution in this form before introducing cross-viscosity concepts.

I am much indebted to Prof. Reiner for attracting my interest to this problem and for giving considerable assistance in many discussions.

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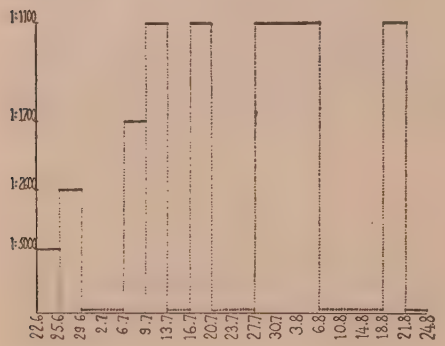
Temporary Adaptation of Trichomonas vaginalis to Aureomycin in vitro

Attempts were made to produce a strain of *T. vaginalis* resistant to the antibiotic aureomycin. A strain was isolated from a case in the outpatient department of the Hadassah-University Rothschild hospital and maintained in bacteria-free culture by the method described by Adler and Pulvertaft[1].

Various concentrations of aureomycin were incorporated into the liquid phase of the medium (the solid phase consisting of a liver-agar slant), in order to test the sensitivity of the strain to the antibiotic. Initially the strain tolerated a maximum concentration of 1 in 5,000 aureomycin but by subinoculating every 3 to 4 days (i.e. the time required for obtaining the maximum population density in a culture on the above medium) into gradually increasing concentrations, good cultures were obtained in a concentration of 1 in 1,100 aureomycin after a period of 21 days which involved 6 passages.

From cultures on the maximum concentration

which permitted growth, subcultures were made on the same and higher concentrations as well as on aureomycin-free medium. In cases where media containing the antibiotic did not favour growth the experiment was carried on with flagellates from the aureomycin-free subculture. After the strain had grown once in 1 in 1,100 aureomycin, it was maintained for one passage on normal aureomycin-free medium, and on testing, was found to maintain its full resistance. This resistance was maintained after two further passages on normal medium. After three more passages on 1 in 1,100 aureomycin it was transferred to normal medium for three passages and was again found to have retained its full resistance. Subsequently it was maintained for four and a half months on normal aureomycin-free medium (from 21.8.52 to 11.1.53) and was found to have lost its resistance completely, i.e., like the parent strain, it tolerated a maximum concentration of 1 in 5,000.



The accompanying graph shows the course of events with one substrain during a period of 63 days involving 18 passages. The continuous lines show the maximum concentration compatible with growth at the time of the experiment. The horizontal dotted lines indicate the periods of growth on aureomycin-free medium.

The above findings indicate that in the case of the above strain of *T. vaginalis* the resistance to aureomycin (which in our experiments was induced fairly rapidly), did not represent a mutational phenomenon but was a temporary adaptation which eventually disappeared completely.

We wish to thank Professor S. Adler for his interest and continued advice in the course of this work.

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Fumigation of Flour With Ethylene Dibromide

The use of methyl bromide has been an accepted practice in the United States for several years. According to the investigations of Raul, Hermitte and Shellenberger[1], it has no harmful effect on the quality of the flour, if used in the prescribed quantities.

The effect of ethylene dibromide on the pests *Calandra Oryzae* and *Tribolium* spp. has been investigated by Aman, Farkas and Plaut[2], and has become the fumigating agent employed in the granaries of Israel. This substance is not so dangerous in handling as hydrocyanic acid or methyl bromide which must be used in vacuums and not readily inflammable, like carbon disulphide which were formerly used for fumigation. Fumigation with ethylene dibromide may be carried out simply by covering the sacks of flour with tent cloth.

In this investigation, the efficiency of ethylene dibromide in the fumigation of flour was tested, and the quality and baking properties of the fumigated flour were determined.

Standard flour (wheat 88% extraction) and white flour (wheat 70% extraction) were examined. Each 2 kg sample of flour contained about 40 insects of the species *Calandra* and *Tribolium*. The fumigation was carried out in closed bins of 20 litre capacity, into which were introduced 2 g liquid ethylene dibromide (100 g/m³). The fumigation period was 72 hours at room temperature (about 28°C). After fumigation, the flour was sieved and the insects were found dead. Ethylene dibromide was therefore found to be efficient for the destruction of these pests in flour. The bins were subsequently left open for a further 72 hours in order to air the contents and assure total eva-

TABLE I

The effect of fumigation on the baking property of flour

Activity	*Moisture* (%)	*Fermentation* (*min*)		*Diastatic activity* (*mg maltose in 10g flour*)		*Moist gluten* (%)		*Vol. of baked sample* (cm³)	
		Normal	*After fumig.*	*Normal*	*After fumig.*	*Normal*	*After fumig.*	*Normal*	*After fumig.*
Standard flour	13.6	39	41	320	310	40.8	40.2	340	352
White flour	12.6			140	150	29.2	28.6	460	451

poration of the ethylene dibromide. Upon testing for residue bromide using fuchsin dichromate[3], no traces of bromide were detected. In fumigated flour left in the open bins, however, insects were again found after three months indicating that their eggs were not destroyed.

The moisture content, gluten (moist)[4], fermentation test number[5], and the diastatic activity were determined[6], and a baking test was carried out. The quality and the "rising" of the dough made from the fumigated flours, both standard and white, were normal and did not differ in any way from standard dough (i.e. appearance, volume, taste).

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Dielectric Measurements by a Modified Standing Wave Method at Microwave Frequencies

A method for measuring the complex propagation constant γ in solids and fluids has been described by Roberts and von Hippel[1,2]. The propagation constant is determined from the standing wave ratio S and the distance x_o of the first minimum from the surface of the dielectric. It can be shown from transmission line theory that the input impedance can be represented by

$$\frac{S - i \tan \frac{360\, x_o}{\lambda_g}}{1 - iS \tan \frac{360\, x_o}{\lambda_g}} = a + ib \qquad (1)$$

where λ_g is the wavelength in the guide. The connection between γ and the input impedance is given by

$$(a+ib)\frac{\lambda_g}{2\pi di} = \frac{\tanh \gamma d}{\gamma d} \qquad (2)$$

where d is the thickness of the dielectric. Since the function $\frac{\tanh \gamma d}{\gamma d}$ is multivalued, there is an infinite number of values of γd which satisfy equation (2). If γ is not known approximately, this ambiguity can be only resolved by repeating the measurements with a sample of different length.

In some measurements of the propagation constant and dielectric constants it is difficult to repeat the experiments under identical conditions. This occurs in cases where large changes of dielectric constants may be expected, as in some chemical reactions, or where the thickness of the sample may change. Moreover, solutions of equation (2) is somewhat involved and one has to utilize charts[1] of the function

$$\frac{\tanh Te^{i\tau}}{Te^{i\tau}} = Ce^{i\zeta}$$

We have found it useful to change the above procedure of measurements for medium and high loss materials. If the dielectric is of very large length d_m, then the electromagnetic wave is completely attenuated. This condition is realised when

$$\tanh \gamma d_m = 1 \qquad (3)$$

In this case equation (2) reduces to

$$\gamma = \frac{2\pi i}{\lambda_g} \frac{1}{a+ib} = \alpha + i\beta \qquad (4)$$

It is to be noted that one measurement of S and x_o will determine γ unambiguously. By following changes in S and x_o, one can determine changes in γ and the dielectric constant ε' and the loss factor ε'' without involved computations. The measurement of γ is now independent of the length of the dielectric, which makes this method most suitable for measuring samples which shrink or expand with temperature changes. The nature of the short circuit does not influence the final result.

It is interesting to find the relationship between the minimum length d_m of the dielectric sample and the attenuation constant α. Equation (3) can be reduced to $e^{-2\alpha d_m} = 0$ as the only physical possibility. If we are satisfied with an accuracy of 1% in the measurement of α then

$$e^{-2\alpha d_m} < 0.01$$

$$d_m > \frac{2.5}{\alpha} \qquad (5)$$

The adjoining graph shows the relationship of ε' and α for dissipation factors $\tan \Theta = \frac{\varepsilon''}{\varepsilon'}$, ranging from 0.1 to 1 at the wavelength 3.14 cm. From this graph the minimum length d_m can be determined by means of equation (5). For glycerine an absorption cell of 1.5 cm, and for water a cell of 0.7 cm would be adequate. Experimentally it is fairly easy to check whether the dielectric is

of the minimum length. If on removing the short-circuiting end plate neither S or x_o change, this is a sufficient indication that the wave is completely attenuated. The knowledge of condition (3) takes here the place of a second measurement of S and x_o with a different sample length as required in the conventional method.

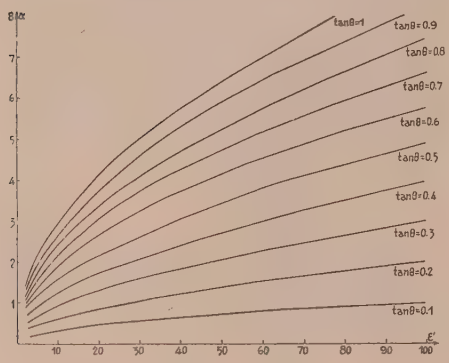

Figure 1

We have measured a number of medium and high loss fluids and solids with this method. Table I shows a few representative measurements of ε' and ε'' on fluids. The results are in agreement with those found by other workers using various methods.

TABLE I

Substance	*Temp.* (°C)	ε'	$\tan\Theta$
Water	18	59.4	.545
Glycerine (U.S.P.)	19	5.3	.375
Gelatin (25 g in 100 g water)	17	42.7	.64

This method has some disadvantages. An analysis of equation (3) shows that x_o is always less than $\frac{\lambda_g}{2}$ and for most substances very nearly $\frac{\lambda_g}{2}$. Therefore, $\tan\frac{360\ x_o}{\lambda_g}$ is very small and even a relatively small error in the measurement of x_o will significantly effect the final result of ε' and ε''. This method requires an extremely well built standing wavemeter with micrometer drive of better than 0.01 mm in the 3 cm wavelength range. Moreover, this method is limited to samples of high and medium dissipation factor. Low loss materials would require a very large cell, x_o and S would be very small, and the determination of γ not very accurate.

The authors wish to thank Dr. E. Alexander for helpful discussion and Mr. Loewensohn, head of the machine shop of the Dept. of Physics, for construction of the standing wavemeter.

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Microwave Measurements of the Dielectric Constant of some Powdered Solids

As part of the progamme of investigations of the dielectric constant of gels, hydrates, adsorbed water and 'bound water' at microwave frequencies, we have measured the dielectric constant of a number of powdered solids. These measurements were made by standing wave technique at 3.1 cm. Conductivity corrections were negligible in most cases and the dissipation factors measured are mainly due to relaxation of polar molecules. Whenever changes of dielectric constant with temperature were investigated corrections for thermal expansion of the absorption cell were made.

A number of theories[1,2,3,4,5] have been formulated which connect the static dielectric constant of a solid ε_1 with that of a powder ε if the partial volume δ is known. Assuming that the relaxation frequency of sodium chloride is far removed from the microwave region so that these formulae are applicable we have tested these theories by measuring the dielectric constant of NaCl. The formula of Boettcher[4], derived for spherical particles

$$\frac{\varepsilon-1}{3\varepsilon} = \delta\frac{\varepsilon_1-1}{\varepsilon_1+2\varepsilon}$$

has been found to give best results. The value computed for NaCl (see table) compares favourably with the experimental value of 5.6, measured on a single crystal at low frequencies[6].

Van Vessem[7] has shown experimentally that Boettcher's formula is a good approximation only when the grain size of the particles is negligible compared with the dimensions of the condensor. We have observed similar variations of the dielectric constant with grain size. Electromagnetic scattering due to the particles is considered negligible at 3 cm.

Polder and van Santen[5] have generalized Boettcher's theory for particles of various shapes. From their results it can be inferred, for the low dielectric constant here considered, that the shape of the particles will not change the dielectric con-

stant as computed by Boettcher's formula by more than 5%.

Results obtained for NaCl, $CuSO_4.5H_2O$, and gelatin powder are given in the table. The dielectric constant of copper sulphate at room temperature is computed to be 5.85. This value should be compared with the old values of 5.5 and 7.8 as listed in I.C.T., measured on powdered crystals at low frequencies and using Wiener's formula[3]. The accompanying graph shows the variation of the dielectric constant and the dissipation factor tan Θ with temperature. The slow variation of

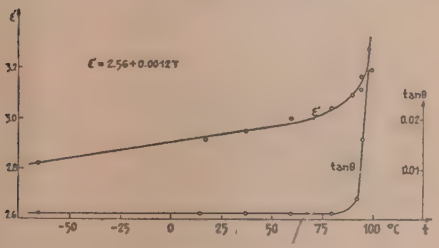

Figure 1

the dielectric constant with temperature can be explained[8] to be due to the change of the number of dipoles which can orient into a equilibrium positions. This number increases with the temperature. No structural transitions, similar as reported in a number of alums[9], has been observed. This does not exclude the possibility that such transitions may occur at lower temperatures.

Between 92°C and 99°C there is a relatively large increase of the dielectric constant and dissipation factor. Up to this temperature the process is reversible and shows only a small temperature hysteresis. At 99°C there is a sharp increase of the constants and the process ceases to be reversible. The volume of the copper sulphate shrinks and water is condensed on the mica. Apparently there is a loosening of the structure between 92—99°C and above this temperature water is liberated, thus giving this large dielectric constant. Qualitative absorption measurements were made up to 150°, where a similar increase of attenuation was found. Presumably the fifth, more tightly bound water molecule is liberated at 150°C.

The dielectric constant of gelatin cannot be determined from that of the powder, as the partial volume is unknown. Reasonable estimates of δ indicate a dielectric constant of 3.5—4. The dissipation factor of gelatin powder is rather high. Bayley[10], working at somewhat lower frequencies on a number of proteins has found dissipation factors of the same order of magnitude and suggested that they may be due to adsorbed water. The possibility of resonance absorption[11], while unlikely, cannot be excluded. In view of the importance of these measurements for biological problems, further work at different temperatures and frequencies and carefully controlled conditions may be advisable.

Variation of the dielectric constant of a 20% gelatin solution with temperature have been measured. No definite indication of changes of dielectric constant in sol-gel transitions have been found (to be published).

We have also investigated the changes of dielectric constant of calcium chloride with hydration. The dielectric constant changes from a very large value to smaller value within a short time after adding a known quantity of water. This could possibly be explained as a change of the position of the water molecule from adsorbed or rotationally 'free' water to crystalline or 'bound' water. Since the reaction proceeds very fast quantitative measurements are difficult. Our results on calcium chloride are at variance with those found by Rohmer[12].

TABLE

Substance	*ε powder*	*tan Θ*	*Partial volume δ*	*ε₁ (solid)*
NaCl	2.92	0.002	0.56	5.4
$CuSO_4.5H_2O$	2.92	0.002	0.53	5.85
Gelatin	2.1	0.03	density 0.65g/cm3	

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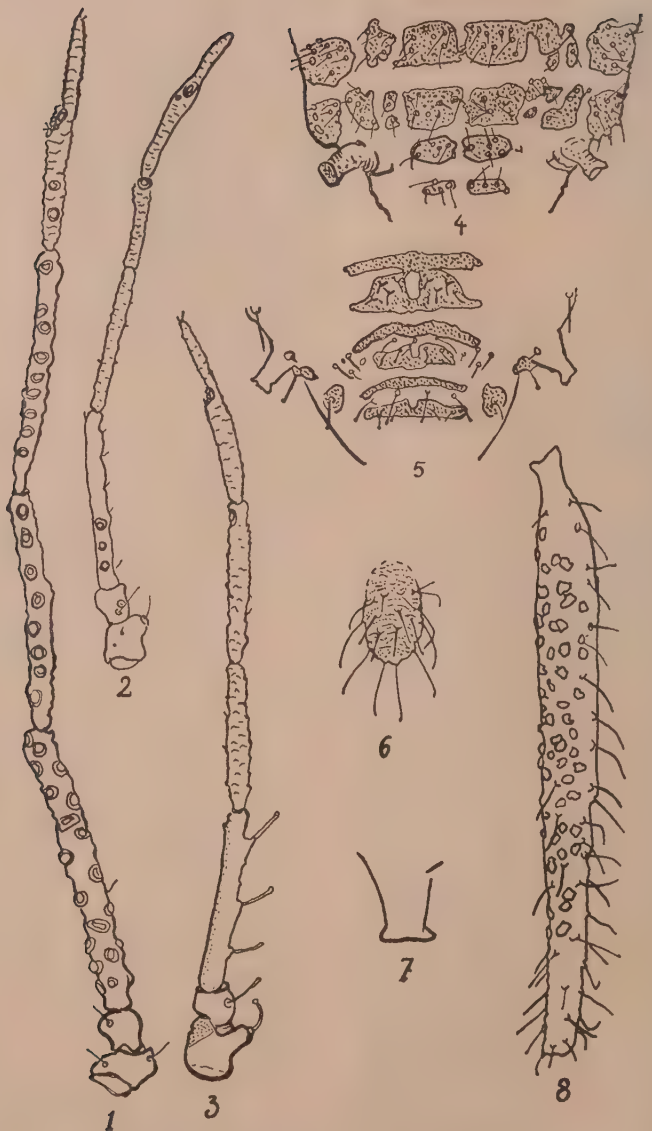
Myzocallis bodenheimeri H.R.L. (Aphidoidea, Homop.) in Israel

These aphids are found on the lower side of the leaves of *Quercus ithaburensis*. They reproduce parthenogenetically throughout spring, summer and autumn. Males and oviparous females appear in December (males in lower percentage). The eggs are laid on branches and in axils of buds, and they hatch in spring (in 1947 in February).



Myzocallis bodenheimeri H.R.L. 1. Antenna of male. 2. Antenna of alate viviparous female. 3. Antenna of oviparous female. 4. Abdominal sclerites of oviparous female. 5. Abdominal sclerites of alate viviparous female. 6. Cauda of alate viviparous female. 7. Cornicle of alate viviparous female. 8. Hind tibia of oviparous female.

Lengths in mm.

	Body	*Antenna*				*Hind leg*		*Cornicle*	*Cauda*
		III	*IV*	*V*	*VI*	*Femur*	*Tibia*		
Male	1.72	1.31	0.34	0.29	0.26	0.17 + 0.11	0.42	0.78	0.06	0.07
Female	2.07	0.95	0.23	0.18	0.18	0.14 + 0.09	0.42	0.71	0.09	0.07

Then the parthenogenetic reproduction starts. In the Jerusalem area the aphids are abundant in spring, less so in autumn, and are sparse in summer.

Alate viviparous females and nymphs have been described by Hille Ris Lambers[1]. Males and oviparous females are described below.

Male. Head with very prominent dome-like process between the lower antennal tubercles (as in alatae). Antennae about 7/10 length of the body; they are longer than those of alatae; joint III of the antennae is longer than IV, V, VI; joints IV and V are about equal, the base of VI is longer than the flagellum (5/11—6/11); secondary sensoria: III, 20—23; IV, 6—11; V, 5—9; VI, 0—2; the sensoria are large and those of III cover all the joint irregularly. Proportion of the hind femur to the tibia, 4/6—6/10. Venation normal. Abdomen, as in alatae, on all tergites with rectangular or oval spinal sclerites, some of them with a central perforation, median incision from the anterior margin present in most of the sclerites in alatae, in the male it is present only in the first and weakly developed in the second. Cornicles and cauda as in alatae. Length of body, 1.7—1.9 mm.

Colour: Head greenish brown, thoracic lobes, sclerites of abdomen and genitalia brown, cornicles and cauda greenish brown.

Oviparous female. The median process in head not prominent as in alatae and males. Antennae about 5/10 length of the body; joint III of the antennae is longer than the joints IV, V, VI, the base of VI is longer than the flagellum (6/11—7/11); I with a prominent process; one long hair on I and II, 3 long hairs on III (about as long as diameter of III); secondary sensoria absent. Hind tibiae flattened and expanded and bear numerous sensoria. Proportion of hind femur to the tibia, 6/10 approximately. On the thorax and abdomen up to between the cornicles is a double row of oval or rectangular spinal sclerites, all of them have a paler centre, and in the hind ones the anterior part is also pale. Parallel to them are marginal and pleural sclerites of which the last ones are broken behind the cornicles are a pair of small weakly developed spinal sclerites with long hairs on all of them. Cornicles and cauda as in alatae.

Length of body, 2.00—2.09 mm.

Colour: Greenish yellow, the sclerites are brown.

The author wishes to express his thanks to Prof. Bodenheimer for his help, to Dr. Hille Ris Lambers for the determination of the material, and to Mr. Amitai for drawings.

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A Method for Determining the Flight Range of Aedes aegypti (Linn.)

Many experiments have been reported dealing with the flight range and dispersion of various species of mosquitoes especially of the genus *Anopheles*. Two methods have been commonly used. One employs the mass liberation at central points of moquitoes marked by means of dyes, powders or radioactive compounds followed by the recapture of the marked specimens. The other employs observation of dispersal from naturally occurring breeding places. Neither method is very satisfactory. The first involve the tedious labour of recapture and identifications of marked individuals and sometimes the use of expensive traps; even under optimum conditions, the percentage of recovery is rather small, and generally below one per cent. The second method is also of limited usefulness, as but rarely dispersal from a single breeding place can be studied. As to *A. aegypti*, data on the flight range are rather meager; it is assumed to have a narrow range of dispersal. Studies on this subject were made by Dunn[1], Shannon[2] and Shannon and Davis[3]. The latter showed a sustained flight over open water of 1000 meters by employing stained specimens. This was the farthest flight range of *A. aegypti* that had been recorded in the literature. More recently Bugher and Taylor[4] using *A. aegypti* marked with radioactive isotopes obtained a maximum flight range of 3,800 feet (1,160 metres) but in these experiments they found that the mosquitoes were distributed largely by wind drift.

In the present investigation a method has been devised for the study of the flight range and dispersal of *A. aegypti*. A large number of gravid insects bred in the laboratory are liberated in the centre of a given area free from any habitation,

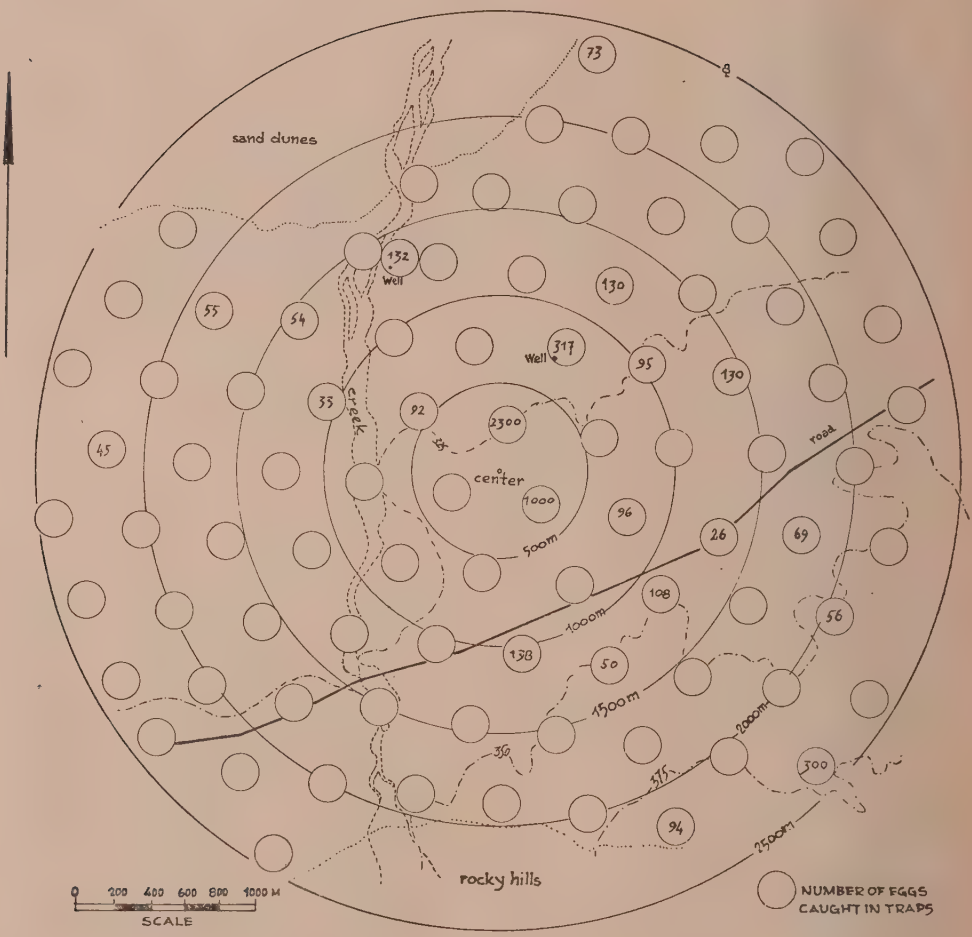

Figure 1

uninfluenced by other factors which might attract the mosquitoes, and free of wild *A. aegypti*. The eggs are collected at different distances from the point of liberation. The mosquitoes were given their first blood meal on white rats in the laboratory three days before liberation. For the collection of the eggs, jars of 4 litre capacity lined with absorbent paper, placed in wooden boxes (50 cm × 29 cm × 23 cm), and distributed over a circular area of 2.5 km radius. The jars were filled with water up to 5 cm from the upper edge of the adsorbent paper. Collection of eggs started on the morning after liberation which had taken place towards evening, and lasted till evening so that within 24 hours after liberation all the jars had been examined. On the second and third day, the same procedure of egg collection was followed.

Two experiments were carried out in a desert area in Southern Israel.

In the first experiment which took place in August 1952, 45,000 gravid females 16 days after emergence were liberated at 1800 hours at the centre of the area. Meteorological data indicated the absence of wind during the period of the experiment. 86 jars were distributed over the area so that the distance from one jar to the next was 500 m. Eggs were laid only within the first 24 hours. 5393 eggs were counted in 20 jars giving an average of 0.12 eggs recovered per female liberated (Figure 1). By dividing the area in concentric circles of increasing radius of 500 meters

from the centre (Figure 1) it can be seen that most eggs (61.2%) were laid within a distance of 500 meters from the centre, a large number, however, (38.8%) were at distances beyond 500 meters and about 10 per cent at a distance of 2—2.5 km from the point of liberation.

In the second experiment which took place in September 1952, 28,000 gravid females 16 days old were liberated at 1900 hours at the centre of the experimental area. During the experiment a westerly wind (1—5 km/hr) prevailed. In this case 73 additional jars were added at the centre of the area within a circle having a radius of 800 meters so that the distance between the jars in the inner circle was reduced to 166 meters while remaining at 500 meters in the rest of the area. In this experiment also, eggs were laid only within 24 hours after liberation. 3971 eggs were laid in 23 jars giving an average of 0.14 eggs per female liberated (Figure 2).

If the area is divided into quadrants with the direction of the wind as axis, than 80 per cent of the total eggs laid were in the 45°—135° quadrant, i.e. under an angle the opening of which does not deviate more than 45° from the wind direction. No eggs were found west of the centre of the experimental area. In this experiment, as in the first one, eggs were laid up to a distance of 2.5 km from the point of liberation. Laboratory observations indicate that one can assume an average of 50 eggs per female ovipositing in 24 hours. This shows that in the first experiment 0.24% of the total number of females liberated entered the jars to oviposit; in the second experiment 0.28%. This compares favourably with the average percentage of catch, reported by other

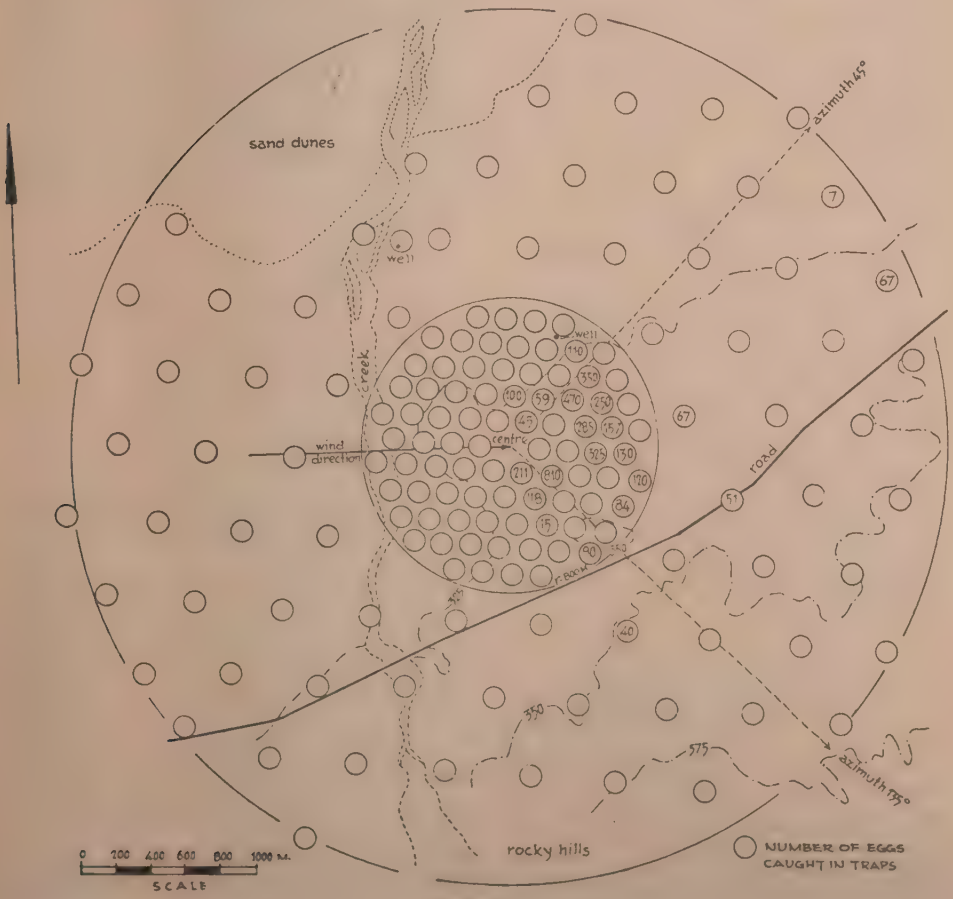

Figure 2

investigators, who used the method of recapture of marked mosquitoes.

It is worthy of note that in the absence of wind (first experiment) the dispersal was greater and more homogeneous than in the presence of wind (second experiment). As according to laboratory observations mosquitoes will not fly in the presence of even slight air currents (1—2 km/hr) except as a result of mechanical stimulus; flight activity may indeed have been reduced by the wind.

Both experiments prove that under the experimental conditions used, the flight range of *A. aegypti* may reach at least 2.5 km within a period of 24 hours.

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Experiments on Light Transmission through some Animal Integuments

(In the Ultra-Violet, Visible and Infrared Regions, 0.2—14 μ)

In order to explain the appearance of many black animals in the diurnal fauna of deserts, the transmission of solar radiation through integuments of such animals as lizards and insects was measured. For comparison's sake, translucent wings and integuments of other colourations were also measured. Apart from the translucent integuments, the results were surprisingly uniform showing negligible transmission in the ultraviolet range, a slow rise in the visible part of the spectrum and high transmission within the infrared range. Various integuments of various colours and sizes showed only very little differences but a rather surprisingly general trend apparently based upon the common basic physico-chemical structure.

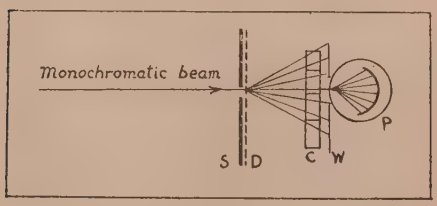

Figure 1
Relative positions of the exit slit of monochrometer S, filter diaphragm D, cell compartment C and phototube P in the Beckman spectrophotometer

Measurements in the wave length region 0.2—1.2 μ

Monochromatic light rays were transmitted through the wings and elytra of several insects and the skin of some lizards. The apparatus used was the Beckman D.U. Spectrophotometer, and the samples were examined by introducing them into holes in the filter diaphragm D (Figure 1). Measurements were made by comparing the intensity of monochromatic light reaching the phototube through the sample under examination with that passing through a hole (of the same size) in the diaphragm. As seen from Figure 1, the sample was introduced into the optical path of the monochromotic radiation near the exit slit of the spectrophotometer, and the distance (DW) between the sample and the window (W) of the phototube was about 4.5 cm. As light is scattered when passing through the sample, only part of the transmitted light reached the phototube. The measurements, thus give too low values of the transmission. Therefore in a new arrangement, the samples were introduced in the front of the cell compartment (C) near the phototube. The distance (CW) between the phototube and the sample was now less than 1 cm—a sufficiently small distance to assume that most of the transmitted light reached the phototube (the surface area of its window being about 4 cm²). Figure 2

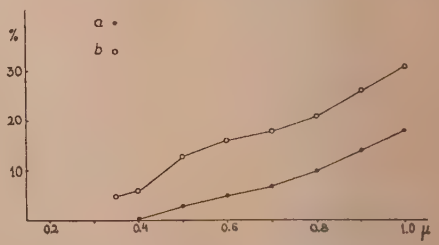

Figure 2
Comparison between transmission values obtained by introducing the sample near the exit slit and near the phototube (see text), curves a and b respectively.

gives the transmission curves obtained with the same samples using the first and the second methods, the difference in the transmission values being due to the scattering effect obtained using the first method. The second method was adopted in all the measurements (Figure 3).

Measurements in the infrared region (1—14 μ)

The apparatus used was the Beckman I.R.2 (sodium chloride optics). Unfortunately the construction of this apparatus prevented suitable positioning of the samples, and most of the scattered light did not fall on the light-sensitive device in the apparatus. Consequently, the results given represent only that part of the transmitted light

which passed through the samples at small scattering angles. As scattering diminishes at longer wave lengths, however, the values obtained by the measurements can be regarded as close to the full transmission values of these wave lengths (Figure 4). The effect of scattering is easily seen, when comparing the measured values of transmission as obtained for the same samples in the range 1—1.2 μ (Figures 3, 4).

In addition to the above, measurements were carried out also on the elytra of *Blaps* sp. (Coleoptera) and the dorsal integument of *Chalcides*

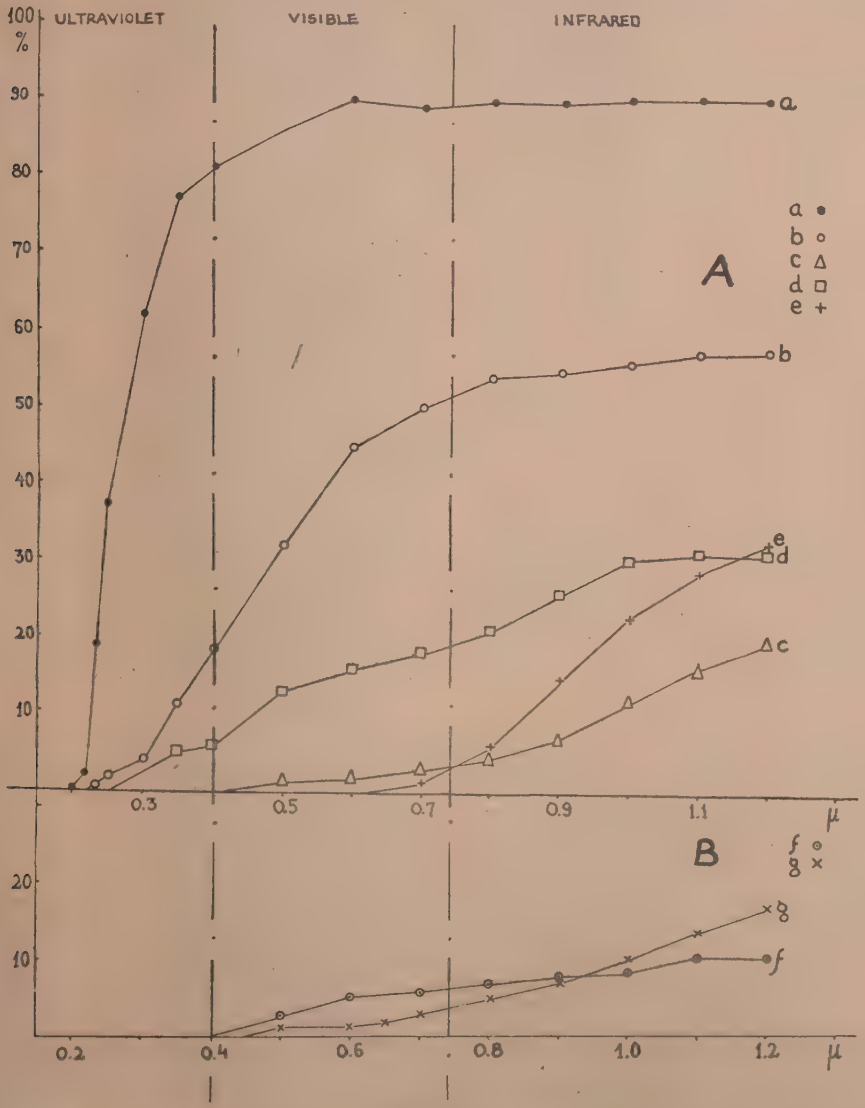

Figure 3

Transmission curves for the wavelength region 0.2 —1.2 μ. A: a—forewing of *Crocothemis* (Odonata), b—hind wing of *Scarabeus* (Coleoptera), c—hind wing of Lycaenidae (Lepidoptera), d—fore wing of *Belenois* (Pieridae, Lepidoptera), e—fore wing of *Blaps* (Coleoptera). — B: f—skin of abdomen of *Chalcides ocellatus*, g—skin of back of *Chalcides ocellatus* (Reptilia).

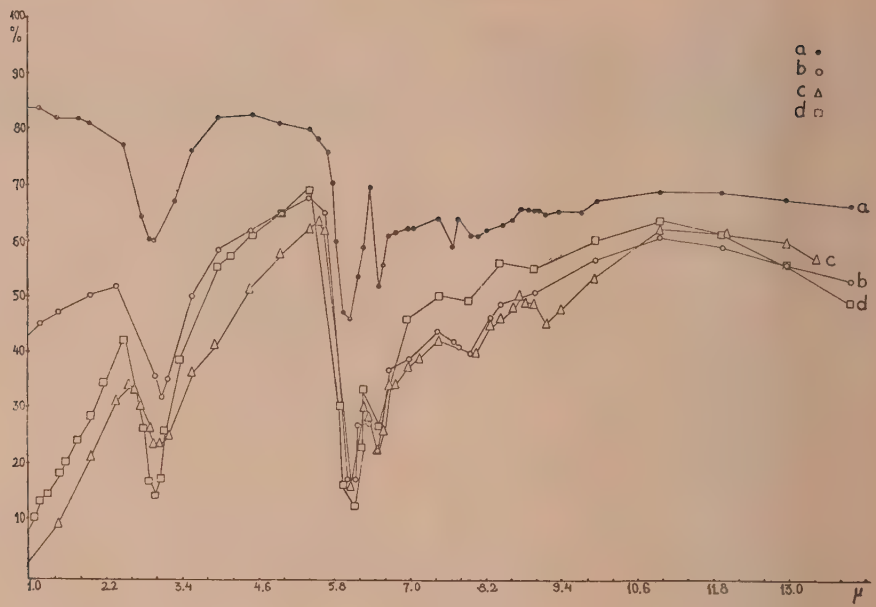

Figure 4

Transmission curves for the wavelength region 1—14 μ. a—fore wing of *Crocothemis* (Odonata), b—hind wing of *Scarabeus* (Coleoptera), c—hind wing of Lycaenidae (Lepidoptera), d—fore wing of *Belenois* (Pieridae, Lepidoptera).

ocellatus (Reptilia). Considering, however, the large scattering in these two species, the apparent transmission values obtained were too low to be considered here. The large scattering in these samples is due to the thick skin and possibly also to differences in the size of the reflecting particles in the skin tissue.

Discussion

Transmission of infrared radiation supplies heat to the animal. The benefit of this black, desert animals cannot be defined. (Prof. Thornton pointed out in a discussion that black colouration possibly reduces transpiration)[1]. The absorption bands at 3 μ, 6 μ, and others which are less pronounced, are due to the chemical structure of the integument. The absorption bands in the 3 μ, 6 μ and 6.4 μ regions are due to the amide groups of the protein molecule.

The amount of ultraviolet transmission through integument of any colour is certainly too negligible to be of any physiological importance. We may be sure, however, that insect, reptile and similar integumental structures even under desert conditions prevent ultraviolet transmission into the body tissue.

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On the Tremor of 28.12.52 in the Galilee and Carmel areas

Thanks to the cooperation of a number of inhabitants of the areas dealt with in this note, the following record has been made possible.

On Sunday 28.12.52 at 4.40 (till 4.45 according to some clocks), after a pause of a whole year (the last tremor occurred on 31.1.51) a small tremor took place in the north of the country. Data have been recorded from about 50 sites in Israel (unfortunately we could not obtain information from Jordan). The data indicate that the pleistoseismical area, of an intensity of 4 at most, was in the area of Nazareth. On the other hand, the quake in the area of Tayibe (near Tulkarm) an intensity 3 indicates that they might be a nucleus of this intensity in Samaria which is known for its seismic activity. There are reports of slight seismic activity in Jerusalem. In Tel Aviv,

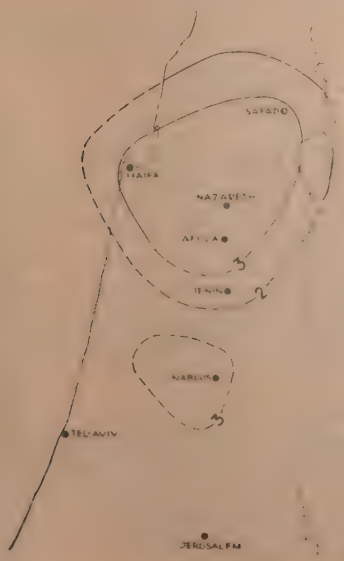
which is nearer the centre of the tremor, it seems it was not felt at all.

In the urban settlements such as Safed, Nazareth and Haifa seismic activity seemed to be greater than in their immediate vicinity probably due to the density of population and buildings. A second shock, slighter than the first, which was reported in Haifa on 10.1.53 does not seem to be founded.

The general charcteristics of seismicity in Palestine and details of the last tremor (31.1.52) have been considered in a recent account[1]. Here the seismicity of the Galilee and Carmel areas will be briefly considered.

Owing to the development of Haifa and its outskirts, it is impossible to consider better the character of the Carmel seismicity. This region was quoted in "The Prophecy of the Signs" (12th century) as a place doomed to suffer earthquakes, but data have been recorded only since the disastrous earthquake of 1837 in the Upper Galilee. In 1856 and 1949 two seismical waves (tsunamis) were noticed, repercussions of the earthquake in Greece. The literature mentions frequent tsunamis that hit the Lévantine coast, some of which had very ruinous effects.

The few data that we have from 1837 to 1927, mark tremors common to the Carmel and Galilee areas. There is no doubt, however, that these were not localized shocks and therefore were felt in the surrounding areas as well. Since 1940 we have found that there were 16 slight quakes, which only in few cases reached an intensity of the fifth degree (15.9.1949). These quakes generally have their foci in the Carmel or there are feeble echoes of seismical disturbances in the adjacent sea, in the Galilee or in Samaria. One of the characteristics of these shocks, even the slight ones, as in the Safed region is the "rombo" that accompanies the shock.



Seismical research in the Galilee showed us that this region also has local foci and, contrary to the usually accepted opinion, the intensity of these tremors was not so strong.

Since 1927 we have rather regular macroseismical data, and from 1939 thirteen tremors were recorded (many others were probably not registered), showing that the number of annual shocks is 1—2, and their intensity is 2—4 degrees.

In the lower Galilee, thanks to Nazareth with her multiple churches, data were rather consistently recorded. Probably the er-Rene region which was destroyed in 1837 and in 1927 has a seismical importance.

On the seismicity of the Lower Galilee, except for the Tiberias Depression which forms an integral part of the Jordan Rift Valley, we have explicit records since the 3rd century. The data are most probably reliable since 1837, and more detailed only since 1923. Since then 14 quakes were noted with intensities from 3—6 degrees, except the 1927 whose focus was situated outside of this area.

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Fishes Caught off Caesarea, on the Mediterranean Coast of Israel

The fishes listed in this paper were collected in the vicinity of Caesarea, from January 1951 to August 1952. In the shallow water, a shore-seine and a cast-net were employed. Among the rocks the fish were obtained by means of a dip-net and rotenone. In deeper water, beyond the rocks, hooks were used.

The fishes are a part of the collection of the Sea Fisheries Research Station, Caesarea.

The literature dealing with the species of the Israeli Coast, is rather limited: W. Steinitz[1] determined fishes from Haifa-Bay, Liebman[2], Hornell[3] and Bodenheimer[4] listed the more common fishes from the Mediterranean Coast of Palestine, Haas and Steinitz[5] identified 10 Erythrean species, which have immigrated through the Suez Canal and H. Steinitz[6] described in detail the family BLENNIIDAE.

This paper deals only with the fish found in the littoral zone. Up to the present time, 39 fishes have been collected, representing 18 families.

In the shallow water off the beach the most common fishes found, were: *Caesiomorus glaucus*, *Mugil auratus*, *Mugil saliens*, *Mugil chelo*, *Diplodus sargus*, *Diplodus vulgaris*, *Pagellus mormyrus*, *Atherina mocho* and *Atherina pinguis*.

Among the rock pools the fish species most frequently encountered were: *Blennius pavo*, *B. gattorugine*, *B. galerita*, *Gobius cruentatus*, *Thalassoma pavo*, *Crenilabrus quinquemaculatus*, *Diplodus sargus*, *Boops salpa*, *Siganus rivulatus* and *Cyprinodon dispar*, found only in the winter months and reported already from Tel Aviv and Athlith by Mendelsohn[7].

Four of the fishes listed here are of Erythrean origin, namely: *Atherina pinguis*, *Siganus rivulatus*, *Cyprinodon dispar* and *Leiognathus klunzingeri*.

On 19.XII.1951, after heavy rains, thousands of *Tilapia zillii* and *Gambusia affinis* were found dead on the shores. They had been carried off to the sea by small streams (Hefzibah and Alexander) swollen by the winter flood waters.

Most of the nomenclature used in the following list of fishes is adopted from Fowler[8].

ENGRAULIDAE

1. *Engraulis encrasicolus* (Linné)

CLUPEIDAE

2. *Sardinella aurita* Valenciennes

HEMIRAMPHIDAE

3. *Hemiramphus* sp.

ATHERINIDAE

4. *Atherina pinguis* Lacepede
5. *Atherina mocho* Cuvier & Valenciennes

MUGILIDAE

6. *Mugil cephalus* Linné
7. *Mugil saliens* Risso
8. *Mugil auratus* Risso
9. *Mugil labeo* Cuvier
10. *Mugil provensalis* Risso

SERRANIDAE

11. *Serranus guaza* (Linné)
12. *Serranus aeneus* Geoffroy St.-Hilaire
13. *Paracentropristis cabrilla* (Linné)

SPARIDAE

14. *Pagellus mormyrus* (Linné)
15. *Diplodus sargus* (Linné)
16. *Diplodus vulgaris* (Geoffroy St.-Hilaire)
17. *Diplodus annularis* (Linné)
18. *Sarpa salpa* (Linné)
19. *Boops boops* (Linné)

CARANGIDAE

20. *Caesiomorus glaucus* (Linné)
21. *Trachurus mediterraneus* (Steindachner)

SCIAENIDAE

22. *Johnius hololepidotus* (Lacepede)

LEIOGNATHIDAE

23. *Leiognathus klunzingeri* Steindachner

SIGANIDAE

24. *Siganus rivulatus* (Forskal)

LABRIDAE

25. *Thalassoma pavo* (Linné)
26. *Crenilabrus quinquemaculatus* Bloch-Schneider

CEPHALACANTHIDAE

27. *Cephalacanthus volitans* (Linné)

GOBIIDAE

28. *Gobius cruentatus* Linné
29. *Gobius sp.*

BLENNIIDAE

30. *Blennius pavo* Risso
31. *Blennius gattorugine* Bruennich
32. *Blennius galerita* Linné
33. *Blennius sphinx* Cuvier & Valenciennes
34. *Blennius canevae* Vinciguerra
35. *Blennius zvonimiri* Colombatovic

BALISTIDAE

36. *Balistes carolinensis* Gmelin

CYPRINODONTIDAE

37. *Cyprinodon dispar* Rueppell
38. *Gambusia affinis* Girard

CICHLIDAE

39. *Tilapia zillii* (Gervais)

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Decapod Crustaceans in the Collection of the Sea Fisheries Research Station, Caesarea, Israel

The collection of Decapods in the littoral zone of the Israeli coast was accomplished during the years 1946—1951. The animals were collected in different ways; some of them were caught ac-

cidentally in the trawl nets, others were found in the course of bottom fauna investigations of the fishing grounds, as well as of the rock-pools in the vicinity of Caesarea.

Though the list contains species already mentioned in the literature (Bodenheimer, 1935; Gruvel, 1931; Steinitz, 1933[3]), it adds a few species which are not yet reported from the Israeli coast. The following literature was used in the determination of species: Bouvier, 1908; Bouvier, 1940; Pesta, 1918.

DECAPODA NATANTIA BOAS

* *Penaeus semisulcatus* de Haan
* *Penaeus trisulcatus* Leach
* *Penaeus japonicus* Sp.-Bate
* *Parapenaeus longirostris* (Lucas)
* *Penaeopsis monoceros* Fabricius
Solenocera membranacea (M.-Edw.)
Aristeus antennatus Risso
Aristeomorpha foliacea (Risso)
Alpheus ruber M.-Edw.
* *Leander squilla* var. *elegans* (Rathke)
* *Leander xiphias* (Risso)
Processa canaliculata (Leach)
* *Aegeon cataphractus* (Olivi)

DECAPODA REPTANTIA BOAS.

* *Scyllarides latus* (Latreille)
* *Scyllarus arctus* (Linné)
Jaxea nocturna Nardo
Upogebia littoralis (Risso)
* *Calianassa stebbingi* Borradaile
Pagurus arrosor (Herbst)
Pagurus calidus Risso
* *Diogenes pugilator* (Roux)
* *Clibanarius misanthropus* (Risso)
Eupagurus excavatus (Herbst)
Galathea intermedia Lilljeborg
* *Porcellana platycheles* (Pennant)
Dromia vulgaris M.-Edw.
* *Dorippe lanata* (Linné)
* *Myra fugax* (Fabricius)
* *Macropodia longirostris* (Fabricius)
* *Inachus dorsettensis* (Pennant)
* *Acanthonyx lunulatus* (Risso)
Pisa nodipes Leach
Pisa ? *armata* Latreille
* *Maia squinado* (Herbst)
Lambrus massena (Roux)
Portumnus latipes (Pennant)
* *Portunus depurator* (Linné)
Portunus pusillus Leach
Portunus corrugatus (Pennant)
* *Neptunus pelagicus* (Linné)
* *Charybdis merguiensis* de Man
* *Pilumnus hirtellus* (Linné)
* *Xantho hydrophilus* (Herbst)
Xantho ? *floridus* (Montagu)
* *Eriphia spinifrons* (Herbst)
* *Gonoplax angulata* (Pennant)
* *Pachygrapsus marmoratus* Fabricius
* *Pachygrapsus maurus* Lucas
Ocypoda cursor Linné

The Crustacea from the sub-order PENAEIDEA are caught in large quantities by trawl nets along the coast, in all operable areas. The species *Solenocera membranacea* and *Aristeus antennatus* are infrequent.

Among the Crustacea encountered during the survey of the rock-pools in vicinity of Caesarea are to be mentioned the following species: *Alpheus* sp., *Hippolyte* sp., *Leander squilla*, *Clibanarius misanthropus*, *Porcellana platycheles*, *Acanthonyx lunulatus*, *Neptunus pelagicus*, *Pilumnus hirtellus*, *Xantho hydrophilus*, *Eriphia spinifrons*, *Pachygrapsus marmoratus*, *P. maurus*.

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Received November 5, 1952.

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* The species marked with asterisks have already been recorded from the Israeli coast.

Notes on the Zooplankton of Israel Fish Ponds

The continually expanding area of fish ponds which at present covers in this country some 30,000 dunams, constitutes an interesting and ecologically defined habitat for the fresh-water fauna.

The climatic conditions in different localities, extending from the Syrian border to Southern Judea, are reflected in differences of water temperature. The small depth of the ponds (generally not exceeding 1.20 m) accounts for a considerable rise in water temperature during day-time as well as relatively large differences between day and night temperatures. The salinity of the water also varies widely according to the composition of influents and the soil structure, the chlorine content ranging from very low figures to as much as 1100 mg per litre.

The fish ponds are mostly of the eutrophic type. The water of a mature pond has a green to yellowish-brown colouration; its transparency is low or very low, and oxygen content is often down to nil. The relatively abundant plankton population is largely confined to the surface layers, while daily vertical movements and frequent water-blooms may be observed.

Within the scope of this communication it is only possible to list species of three groups, as identified in hundreds of samples collected in various parts of the country over a period of three years.

ROTATORIA

1. *Anuaeropsis navicula coelata* Rousselet
2. *Asplanchna brightwellii* Gosse
3. *A. priodonta* Gosse
4. *A. sieboldi* Leydig
5. *Brachionus angularis* Gosse
6. *B. budapestensis* Daday
7. *B. brevispinus* Ehrb.
8. *B. caudatus* Daday
9. *B. calyciflorus* f. *typica* Pallas
10. *B. capsuliflorus* f. *brevis* Pallas
11. *B. falcatus* Zacharias
12. *B. forficula semireducta* Rodewalt
13. *B. leydigii* Cohn
14. *B. plicatilis* Muller
15. *B. rubens* Ehrb.
16. *Catyphna* sp.
17. *Cephalodella catellina* Muller
18. *C. gibba* Ehrb.
19. *C. ventripes* Dixon
20. *Colloteca* sp.
21. *Colurella bicuspidata deflexa* Ehrb.
22. *Epiphanes mollis* Hempel
23. *Euchlanis dilatata* Ehrb.
24. *E. parva* Rousselet
25. *Filinia longiseta* f. *typica* Ehrb.
26. *F. saltator* (*Pedetes saltator*) Gosse
27. *Keratella cochlearis* Gosse
28. *K. valga tropica* Apstein
29. *Lecane bulla bulla* Murray
30. *L. luna luna* Muller
31. *L. papuana* Murray
32. *Lepadella ovalis* Ehrb.
33. *Lophocharis salpina* Ehrb.
34. *Metadiaschiza trigena*
35. *Notops branchionus spinosus* Ehrb.
36. *Pedalion fennicum* Levander
37. *P. intermedia* Hudson
38. *P. oxyure* Sernov
39. *Polyartra trigla* Ehrb.
40. *P. remata* Carlin
41. *P. vulgaris* Carlin
42. *Pompholyx complanata* Gosse
43. *Proales cryptotus* Wulfert
44. *Ptygura* sp. (melicerta?)
45. *Rotaria elongata* Ehrb.
46. *R. neptunia* Ehrb.
47. *Trichoerca pusilla* Jennings
48. *T. rattus* Goldfuss

COPEPODA

1. *Cyclops strenuus* Fischer
2. *Diaptomus Wierz.* var. *palaestinus* Kiefer
3. *Eucyclops serrulatus* Fischer
4. *Mesocyclops leuckarti* Claus
5. *Metacyclops minutus* Claus
6. *Thermocyclops Dybowski* Lande

CLADOCERA

1. *Alona costata* Sars
2. *A. punctata* Gurney
3. *A. rectangula* Sars
4. *A. quadrangularis* Muller
5. *Bosmina longirostris* Muller
6. *Daphnia carinata* King
7. *D. magna* Strauss
8. *D. pulex* de Geer
9. *Macrotrix hirsuticornis* Norman
10. *M. laticornis* Jurine
11. *Moina dubia* Richardj
12. *M. salinarum* Gurney

The valuable assistance rendered by Prof. V. Brehm of the Lunz Biological Station and by Prof. B. Berseus and Dr. K. Lindberg of the Lund Limnological Institute in the scrutiny and revision of the systematic material, is gratefully acknowledged.

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Summaries of Lectures Presented in the Section on Enteric Pathogens

Salmonella Findings in Israel

Most of the strains of *S. paratyphi A*, *S. paratyphi B* and *S. paratyphi C* were isolated from patients with symptoms of enteric fever. In some cases these three serotypes as well as *S. kottbus*, *S. anatum* and *S. meleagridis* were isolated from the faeces of healthy persons handling foodstuffs. The most common types were *S. typhimurium*, *S. newport* and recently *S. meleagridis*, while *S. enteritidis* was relatively rare. In the last few years there appeared in Israel types which were hitherto unknown: *S. stanleyville*, *S. oslo*, *S. braenderup*, *S. concord*, *S. potsdam*, *S. dublin*, *S. panama*, *S. meleagridis*, *S. taxony*, *S. havana*, *S. worthington*, *S. sundsvall* and *S. gaminara*. Five new strains were isolated in this country: *S. haifa*[1], *S. jerusalem*[2], *S. ness-ziona*[3], *S. emek*[4] and *S. telhashomer*[5].

The total of all serotypes reported hitherto in Israel[6,7] is 44.

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A New Shigella in Israel

From 1949—1951 a new *Shigella* was isolated and recognized in 27 cases of clinical dysentery[1]. It has no serological relationship to previously described dysentery bacilli.

It was found by Ewing (International Shigella Center, U.S.A.) and by S. Szturm-Rubinstein (Pasteur Institute, Paris), that this strain is identical with a new *Shigella* described by Szturm, Piechaud and Neel[2] and by Ewing and Taylor[3], named by Ewing "provisional *Shigella boydii* 10".

In all the 27 cases, the colonies of the strain in the primary cultures were very numerous. the exudate was typical for bacillary dysentery and the clinical picture rather severe.

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A Ward Infection with Serratia marcescens

In the children's ward of a Jerusalem hospital, there appeared a number of cases of infection with *Serratia marcescens*. The clinical symptoms of one of the cases associated with the presence of this bacterium and its morphological and cultural properties are described elsewhere[1,2].

24 hours broth cultures of these bacteria killed mice when 0.03 cc were injected, intraperitoneally.

Aureomycin and chloromycetin inhibited their growth *in vitro*.

A solution of glucose, used for intravenous injections, etc., was found to be contaminated with *S. marcescens*. When this contaminated solution was discarded and the ward was thoroughly cleaned, no more infections occurred.

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An Epidemic of Diarrhoea in Infants Associated with the Appearance of Klebsiellae

244 *Klebsiellae* were isolated and examined during an epidemic of acute gastroenteritis from diseased and healthy children.

Klebsiellae of faecal origin were differentiated from *Escherichiae* by their urease activity and the *IMVIC* reactions. Four groups were described:

* Continuation from Vol. II, No. 2 where summaries of lectures presented in the Virus Section and the Section of General Microbiology and Chemotherapy appeared.

1. Strains which promptly fermented adonitol, inositol and aesculin;

2. Strains which fermented either adonitol or inositol;

3. Fermentation as in group 2, liquefied gelatin;

4. Fermentation as in group 2, slow fermentation of lactose.

900 specimens of faeces and other excretions were examined. Group 1 was isolated in 65% of the specimens and subdivided in more than 9 biotypes by the examination of the utilization of *d*-tartrate, citrate and mucate, fermentation of dulcitol, urease activity and Voges-Proskauer reaction. In one wing of the children's wards, 12 infants died from acute gastroenteritis during this epidemic: types corresponding biochemically to serotype 1:7 and 1:13 as represented in Table 41 of Kauffmann[1] were isolated from urine, faeces, pharynx during life and from lungs, blood and intestinal contents *post mortem* as well. These types, all included in group 1, were isolated from 41% of the patients placed in this building as compared with 16% in the other buildings.

Other biotypes were scattered over the whole hospital and all wings of the children's wards. They were isolated from 53% of all specimens as compared with 7% in the ward where most of the fatal cases occurred.

The division into biotypes is preliminary until their correlation with antigenic structure (capsular types) will be determined.

This research is carried out with the aid of a grant from the Research Council of Israel.

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Method for Isolation and Differentiation of E. coli Serotypes 0-55 and 0-111

Serotypes 0-111 and 0-55 of *E. coli*, isolated in Tel Aviv and surroundings, fermented sorbitol slowly or not at all. Therefore, a medium was used which was identical with that of MacConkey, with the exception that lactose was replaced by *d*-sorbitol at a concentration of 1%. On such medium, *Proteus* and the serotypes 0-111 and 0-55 of *Escherichia* grew overnight as colourless translucent colonies, while other serotypes formed red colonies. Another medium which can be used for the same purpose is Kligler's iron agar, where glucose and lactose were replaced by sorbitol. When inoculated into this medium, an 0-111 or 0-55 colony, grows without gas and with slight anaerobic fermentation; other serotypes of *E. coli* produced gas. and *Proteus* produced H_2S.

These cultural examinations were finally confirmed by slide agglutination with specific antisera.

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Inhibitory Action of some Inorganic Compounds and Antibiotics on the H_2S Production of Salmonellae

Sodium biselenite inhibited the production of H_2S by *S. enteritidis* on Kligler's iron agar (Difco) in a concentration of 0.007 g % in Durham's peptone and in a synthetic medium in a concentration of 0.005 g % while the concentrations required for the inhibition of the gas production were about 10 times higher. The growth ceased in the liquid media at the concentration of 1.0 to 1.25 g%. H_2S production as well as growth were inhibited at the same concentrations by magnesium and calcium thiosulfate.

On the three above-mentioned media, the H_2S production was inhibited by penicillin at concentrations of 7—10 units/ml, while the gas production ceased in the presence of 15—20 units/ml. Growth stopped on Durham peptone at 25 units/ml and on the synthetic medium at 15 units/ml. The widest intervals between the H_2S production inhibiting concentration (7 units), the gas production-inhibiting concentration (15 units) and the growth-inhibiting concentration (25 units) was observed on Durham's peptone.

To a synthetic medium which contained as the sole organic compounds: 0.05% sodium citrate-0.2% glucose, 0.0025% sulphur-containing organic substances were added. H_2S was produced in abundant quantities from cysteine and thioglycollate, while in the presence of methionine and homocysteine, H_2S was not formed. When $MgCl_2$ was replaced by 0.01% $MgSO_4$, a weak formation of H_2S took place. In the presence of cysteine, the growth-inhibiting concentration of penicillin was 6 units/ml, the H_2S production inhibiting concentration 10 units/ml. The addition of methionine, serin, threonin, homocysteine and a mixture of amino acids (*l*-arginine, *l*-histidine, *dl*-isoleucin, *l*-leucin, *l*-lysin, *dl*-phenylalanine, *l*-tryptophan and *dl*-valine) did not change these levels, while in the presence of thioglycollate, the H_2S production was inhibited at a concentration of 15 units and the growth at 12 units/ml. In the presence of sodium thioglycollate (25 μg/ml) 0.001 ml of penicillase/ml was required in order to enable the formation of H_2S and growth in the presence of 15 units/ml of penicillin after 24 hours,

and 0.0005 ml of penicillase in order to enable appearance of H_2S and growth after 48 hours. Without thioglycollate, the required quantities of penicillase were five times higher since the action of the enzyme was not supported by the partial inactivation of the pencillin by thioglycollate.

Chloromycetin, streptomycin and aureomycin inhibited H_2S production and growth at nearly the same concentrations. The respective concentrations for these three antibiotics were 0.6, 25 and 0.7 μ/ml on Kligler's iron agar and 1.25 and 1.5 μ/ml on Durham's peptone.

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Haemagglutination by a Pseudomonas of Faecal Origin

From the faeces of a healthy adult, a bacterium was isolated which showed the following properties:

Short gram-negative rods, possessing 1—2 polar flagella. They did not ferment carbohydrates, did not reduce nitrate; gelatine was not liquefied, indol and H_2S not formed, pigment was not produced. Bacterial suspensions from 24 hours agar slants showed tube and slide agglutination of human red cells, irrespective of their antigenic structure. Agglutination occurred in a range from 6—56°C and was usually performed at room temperature; it appeared at 6°C after 16 hours, at room temperature after 1½—2 hours and at 56°C after 40 minutes. The presence of 2.4×10^8 bacteria were required for the agglutination of 0.5 cc of a 0.5% red cell suspension and their minimal agglutinating number (M.A.N.) increased proportionally with the concentration of the red cells; when fresh defibrinated blood was employed, the M.A.N. was 12—18 bacteria per one red cell. When the red cells were stored for 8 weeks at 4°C, one bacterium per erythrocyte elicited agglutination and after 10 weeks storage, haemolysis. Red cells washed 10 times in Locke's solution and shadows obtained by haemolysis in distilled water and washed 15 times remained agglutinable.

Agglutinated erythrocytes were not disagglutinated either when kept at 4°C for 48 hours, or by shaking in Locke's solution at 6, 20 or 30°C; however, by shaking with an equal volume of specific anti-*Pseudomonas* serum (titer 1:10,000) prepared by immunization of rabbits with living *Pseudomonas*, for 30 minutes at 30°C and 2 hours at 20°C, the bacteria were agglutinated by their antiserum, formed separate aggregates, and the erythrocytes became free. These disagglutinated cells were reagglutinated by *Pseudomonas* and also by influenza virus. On the other hand, red cells agglutinated by influenza virus and eluted were subsequently agglutinated by *Pseudomonas*. The exposure to the receptor destroying enzyme of *Vibrio comma* deprived the red cells of their agglutinability by influenza virus without diminishing their agglutinability by *Pseudomonas*.

The *Pseudomonas* growing on nutrient agar or on a solid medium which contained glycine or alanine as only source of nitrogen produced haemagglutinin. Cystine, mannitol, sorbitol, dulcitol, lactic acid, NaCl concentration above 1% and pH below 6.6 interfered with haemagglutinin production without affecting growth.

The presence of 0.2 g of sulfadiazine or 1000 units of penicillin per cc of nutrient agar lowered markedly the haemagglutinin production in the first subculture. A streptomycin-resistant mutant isolated from agar containing 1.0 μg/cc of streptomycin did not produce haemagglutinin. A mucoid variant produced by passages through mice did not agglutinate red cells, but by subculturing it several times on broth containing 1% specific anti-serum this ability was gradually restored.

Pseudomonas, kept in Locke's solution or distilled water for 4 months at 6.20 or 37°C, agglutinated red cells although the viable bacterial count approached zero. Exposure of bacterial suspensions to varying temperatures from 50 up to 100°C for periods varying from 2 up to 60 minutes, freezing and thawing, exposure to ultraviolet rays, to low pH, to phenol, formaldehyde, sulfadiazine and antibiotics showed that the haemagglutinating power may persist, even when the viable count approaches zero.

Shaking the bacterial suspensions in 50% ethanol, acetone or ethylacetate for 24 hours at 30°C and tryptic digestion destroyed the haemagglutinin, while shaking with ether, chloroform, toluol and diethylene-glycol was ineffective. The haemagglutinin was not separated from the cells either by washings, heating, irradiation, freezing and thawing, trituration in a ball mill, extraction by solvents or by tryptic digestion.

The haemagglutination by *Pseudomonas* was inhibited in the presence of anti-*Pseudomonas* sera prepared by immunization of rabbits with living bacteria and less with heated bacteria. Anti-mucoid sera did not inhibit haemagglutination.

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Summaries of Lectures Presented in the Section of Protozoology

Immunological Observations on Trypanosoma lewisi[1]

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1. Citri, N., 1952, *Bull. Res. Counc. of Israel*, 1, No. 4, 99.

The General Properties of the Exotoxin of the Phytoflagellate Prymnesium parvum

Prymnesium parvum, a phytoflagellate from brackish water, produces an extracellular toxin which may cause mass-mortality of fish. Such outbreaks of fish mortality have been described from Holland[1], Denmark[2] and Israel[3]. *Prymnesium* first appeared in Israel in 1947 and in a very short time spread throughout the country and became a constant feature of all the brackish water fishponds in this country. The affected area now extends to about 5000 dunams, a quarter of the total local fishpond area.

It was therefore of interest and of economic importance to study the properties of the toxin of *Prymnesium*, in order to better understand the factors which govern the toxicity of this organism in nature[4].

The experiments were carried out with cell-free toxin solutions, obtained from toxic pond water or from laboratory cultures by centrifugation at high speed. A quantitative estimation of the toxin concentration was made by bioassays in which minnows and tadpoles were used as test organisms. The assays were based on the determination of the minimal lethal concentration or on the time interval elapsing until the onset of toxic reactions in the test organisms.

The *Prymnesium* toxin was found to be a heat-labile, non-dialyzable, oxidation sensitive substance which is readily adsorbed on a variety of adsorbents, among them pond-bottom soils. The activity of the toxin is reversibly abolished at pH levels below 7.0. The ready transition from an active into an inactive form and its reversal as a function of pH as well as the other properties described above suggest that the toxin may be a protein.

The toxin has a closely defined range of biological specifity. Besides the many species of fish which are highly susceptible, many amphibia in their gill-breathing stages are also killed by the toxin. Immediately after metamorphosis, however, the tadpoles of all the amphibia tested lose their susceptibility entirely.

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2. Otterstroem, C. V. and Steeman-Nielsen, E., 1939, *Report of the Danish Biological Station*, 44, 5.
3. Reich, K. and Aschner, M., 1947, *Pal. J. Bot. Jer. Ser.*, 4, 14.
4. Shilo (Shelubsky), M. and Aschner, M., 1953, *J. Gen. Microbiol.*, 8, 333.

The Occurrence of Intestinal Parasites in the Rehovot District[1]

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1. Ettinger-Tulczynska, R., 1953, *Harefuah*, 49, (in press).

The Role of the Spleen in the Immune Mechanism against Plasmodium berghei in the Field Vole, Microtus guentheri

The discovery of a new plasmodium, *P. berghei*, in a tree rat in the Belgian Congo[1] gave malariologists the first mammalian plasmodium on which laboratory research on a large scale can conveniently be carried out, since it is readily transferred to laboratory rats, mice, hamsters, voles and other rodents. The large number of hosts, each of which develops a specific type of infection, renders this parasite particularly suitable for comparative studies on host-parasite relationships.

We have begun a series of such studies with an investigation of *P. berghei* infections in the field vole, *Microtus guentheri*[2,3]. Untreated infections in intact voles were in general very mild and transient. Eighty-eight per cent of such voles survived initial infections, most of them with peak parasitemias of less than 20%. Circulating parasites were not microscopically demonstrable after about the second week following inoculation, although an occasional parasite could be found for a week or so after latency first set in.

In view of the primary importance of the spleen in establishing and maintaining immunity in other known malarias, its role was studied with reference to *P. berghei* infection in voles. Splenectomy performed at any time before initial infection or during patency or early latency always led to death from fulminating parasitemia. Thus, the spleen is essential in the functioning of innate immunity of the vole, before and during the acute rise of the infection, when acquired immunity can be ruled out. Since splenectomy performed early in latency, when acquired immunity is in the course of development, also led to death, removal of the spleen interferes with the establishment of efficient acquired immunity.

Late in latency, during a critical period lasting several weeks, splenectomy was followed by either a) death; b) a protracted, low chronic state; or c) radical cure, as demonstrated by the absence of relapse and by the non-infectivity of tissues (spleen macerate or cardiac blood) from cured voles. After the critical period in latency, all surviving voles proved to have cured their infections.

The spleen during the critical period was either still essential to defense in case a); or was necessary in maintaining parasitemia at an occult level but not in protecting voles against death in case b). Its importance in case c) was assessed by re-infecting a series of voles whose cure had previously been demonstrated by splenectomy.

About half of them died of acute parasitemia in a short time (acquired immunity, previously capable of radically curing infection, waned after cure). In about one fifth, a stable chronic state was reached after an acute peak following superinfection (acquired immunity, waning at superinfection, was primed by superinfection to a relatively efficient equilibrium). In about one fifth the chronic state was reached immediately after superinfection with no intervening peaks, a situation similar to that observed when chronic voles are superinfected (relatively efficient acquired immunity still present at superinfection). A few splenectomized voles were able even radically to cure their infections after many months of the chronic state. In these the extra-splenic immune mechanism must have achieved cure.

Thus, the vole spleen, essential in maintaining innate immunity to *P. berghei* and in establishing acquired immunity, can sometimes be dispensed with in the maintenance of acquired immunity once the latter is actively functioning.

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Attempts at Immunisation with Anaplasma

Anaplasma is prevalent in goats and cattle, and seriously interferes with the development of cattle breeding in Israel. In particular, imported cattle from non-infected countries are affected. According to the records of the "Haklaith" during the years 1948—49 1,060 head of cattle developed Anaplasma of which 241 succumbed. Since no specific therapy is available, the problem of passive immunity was raised as the only means of combatting Anaplasma.

Prof. Adler suggested an attempt to immunise cattle with Anaplasma from goats. Although a considerable number of cattle in the field were injected with goat Anaplasma with no visible response, we discontinued these field studies in consideration of the doubts expressed by the veterinary services of the Mandatory Government as to the possibility of transfer of *A. marginale* to cattle from goats in which it may possibly occur in nature.

The Veterinary Institute undertook to study this problem in order to attempt to reduce morbidity and mortality, particularly in imported cattle, by seeking to produce an approporiate immunising vaccine.

Materials and Methods

We employed *A. marginale* from cases of cattle infected in nature. Anaplasma was obtained from goats after splenectomy. Blood infected with *A. centrale* was sent to us from Onderstepoort in South Africa. In order to avoid the possibility of natural infection and to obtain clear parasitemia, we regularly splenectomised a considerable number of the experimental animals, cattle and goats. Adult cattle and calves were arranged in parallel groups, as were intact and splenectomised animals. Animals were examined for extended periods in consideration of the long incubation periods of Anaplasma and of the long periods elapsing between attacks. The extent of infection was studied clinically and microscopically.

Results

1. Anaplasma from goats is specific to goats and does not infect cattle, whether intact or splenectomised. Goat Anaplasma does not protect cattle against *A. marginale*.

2. *A. marginale* and *A. centrale* from cattle are specific to cattle and do not infect splenectomised goats. When cattle Anaplasma is inoculated into goats, the blood of such goats is not infective to calves, although the same inoculum is very infective when administered directly to calves. Goats inoculated with cattle Anaplasma develop no immunity to goat Anaplasma. There is no cross immunity between goat- and cattle-Anaplasma.

3. Each species of cattle Anaplasma immunises against itself in the appropriate host. There is an immunity to superinfection.

4. Adult cattle and calves react similarly to Anaplasma. The disease is more severe in splenectomised than in intact animals.

5. The clinical course of the disease does not reflect the number of parasites in the blood.

6. Cases of Anaplasma from the field do not yield suitable material for a vaccine.

7. Infection with *A. marginale* does not prevent infection with *A. centrale*, and vice versa.

8. The presence of the milder *A. centrale* prevents the severe clinical symptoms and the mortality accompanying later infection with *A. marginale*.

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Anopheline Mosquitoes, D.D.T. and the Epidemiology of Malaria in Israel

Before the introduction of D.D.T., malaria in Israel rose to two peaks each year, with their central points in June and November. The summer peak was associated with *A. sacharovi*, and cases occurred particularly along the coast, in swampy regions in which this mosquito develops, as well as in the Huleh swamps. The autumnal peak in October and November was limited to the interior of the country, to areas where streams and springs are found, in which *A. sergenti* and *A. superpictus* develop; while in December the peak was again associated with a secondary rise in the numbers of *A. sacharovi* in regions with shallow swamps.

In recent years extensive routine antimalaria work in the field and in inhabited areas has resulted in a remarkable decrease in all species of Anophelines, as well as in the incidence of malaria. Among the old inhabitants, the incidence fell from 1091 new cases in 1949 to 842 in 1950 and to only 248 in 1951.

At the same time the following marked changes have occurred in the nature of the malarial curve:

1. The summer peak is being leveled out throughout the country.
2. Most of the new cases now occur in October and not in November.
3. The autumnal season has been shortened by a month, as there are no more new cases in December.
4. The type of morbidity curve is now more or less similar in the coastal regions to that in the interior of the country.

These changes may be explained as follows:

1. The swampy areas in which *A. sacharovi* develops have been greatly reduced by drainage.
2. The number of adult *A. sacharovi*, a house dweller, has been reduced to a minimum by spraying dwellings with D.D.T.
3. An increase in the use of water resources for drinking, irrigation, reservoirs, fish culture, etc., has resulted in a wider dissemination of the breeding places of *A. sergenti*, which is no longer confined to the interior of the country.
4. The reduction in *A. sacharovi* has resulted in a lowering of the spring peak and in a shortening of the autumnal malarial season.
5. The increase in *A. sergenti* which has spread to new breeding places has resulted in similar morbidity curves in the coastal area and in the interior of the country.

Note: *A. superpictus*, which was greatly reduced by frost and snows two years ago has not yet recovered and returned to its "normal" numbers.

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Summaries of Lectures Presented in the Section on Clinical Bacteriology and Serology

A Culture Medium for the Enrichment of Salmonellae and Growth Inhibition of Proteus

Proteus was found to be more sensitive to low pH, to high osmotic pressure and to drying than *Salmonellae*. In order to avoid the overgrowth of *Proteus* and to obtain a higher yield of positive cultures from faeces received for the isolation of *Salmonellae*, the following medium was employed:

Bacto peptone (Difco)	10.0 g
KH_2PO_4	1.6 "
NaCl	8.0 "
H_2O dest pH = 6	1000 ml

The medium was divided into series of four 5 ml portions to each test tube adding 0.5 ml and 0.7 ml of a solution of calcium thiosulfate or 0.9 ml and 1.3 ml of a solution of magnesium thiosulfate prepared as follows:

Ca thiosulfate		*Mg thiosulfate*	
$Na_2S_2O_3$	40 g	$Na_2S_2O_3$	16 g
$CaCl_2$	18 g	$MgCl_2$	14 g
H_2O dist.	100 ml	H_2O	100 ml

These solutions were heated for 30 minutes in an open autoclave without pressure.

The stool was emusified in saline, and 1—2 drops inoculated. After incubation overnight at 37°C, a loopful of the broth was transferred to an SS agar plate.

The calcium and magnesium thiosulfate, added in quite high concentrations inhibited *Proteus* and enriched *Salmonellae*. These compounds maintain the two important requirements for the selective effect: a) constant acidity, by regulating the low pH, b) high osmotic pressure.

It was proved that drying alone does not completely depress *Proteus* but does so after transfer-

ring the culture to the medium containing calcium or magnesium thiosulfate. In both cases: drying and high osmotic pressure, the effect is dehydration to which *Proteus* is more sensitive than *Salmonellae*.

With 133 specimens which were found to be infected with *Salmonellae*: (*S. typhi* 26, *S. paratyphi A* 33, *S. paratyphi B* 38, *S. paratyphi C* 23, *S. london* 13), the following combinations of positive results were obtained with five different culture methods: direct inoculation on SS-agar, enrichment on Mueller-Kauffmann's medium, Na biselenite, Mg and Ca thiosulfate.

TABLE I

The frequency of eight different combinations of positive and negative results with five culture methods simultaneously applied

Methods employed	*Combinations of possitive and negative results observed*							
	1	2	3	4	5	6	7	8
SS-agar direct	+	—	—	—	—	—	+	+
Mueller-Kauffmann	+	—	—	—	+	—	—	—
Sodium biselenite	+	+	+	+	—	—	—	+
Magnesium thiosulfate	+	+	—	+	—	+	+	+
Calcium thiosulfate	+	+	+	+	+	—	+	+
Observed frequency of the combination	29	40	14	20	8	16	4	2

The total numbers of positive results obtained were as follows: by direct inoculation on SS-agar: 35; enrichment on Mueller-Kauffmann's medium: 29; sodium biselenite: 85; magnesium thiosulfate: 111; calcium thiosulfate: 117.

These figures show the highly selective effect of the calcium- and magnesium thiosulfate media as compared with three other culture methods.

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Agglutination of Human Red Cells by Poly-*DL*-lysine Hydrochloride

Poly-lysine agglutinates a saline suspension of washed red cells. This agglutination can be prevented or reversed by addition of human serum, heparin or poly-*l*-aspartic acid.

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The Influence of Chloromycetin on the Antibody Titre in Typhoid Fever

Inhibition of antibody production has been observed in thirteen cases out of eighteen cases of bacteriologically proved typhoid fever treated with chloromycetin.

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Blood Groups in Jews from the Yemen

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The Flora of the Normal Conjunctiva of Healthy People in Israel

The bacterial flora of the normal conjunctiva of several population groups in Jerusalem was investigated.[1]

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REFERENCE

1. BACHRACH, U., GUREVITCH, J., LANDAU, J. and BIRNBAUM, D., 1953, *Acta med. or.*, 12, 10.

Haemagglutination Tests in Tuberculosis and Leprosy

207 sera were tested for Middlebrook-Dubos haemagglutination reaction by the modified technique of Scott and Smith[1]. Of these sera, 86 were from patients with pulmonary tuberculosis, 56 from leprosy patients, and 65 from normal subjects.

The reaction was considered positive when the haemagglutination was present in a dilution of 1:8 or higher.

55.8% of sera from tuberculosis, 67.8% of sera from leprosy patients and 21.5% of sera from the normal subjects yielded positive results.

The mean titre of the sera of tuberculosis and leprosy patients was significantly higher than that of normal controls. They were 22.9, 54.2 and 3.3 respectively.

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REFERENCE

1. Scott, N. B. and Smith, D. T., 1950, *J. Lab. clin. Med.*, 35, 303.

Haemagglutination Test in Female Sterility

Genital tuberculosis is a frequent cause of sterility in Jewish women in Israel. 3—4% of women suffering from sterility in this country are affected by endometrial tuberculosis, as shown by endometrial biopsies performed routinely in those patients[1,2]. Endometrial tuberculosis is almost always secondary to the tubal involvement, tuberculous salpingitis occuring at least twice as frequently as endometritis. It might be, therefore, assumed that genital tuberculosis (salpingitis plus endometritis) may occur approximately in 7% of our sterility patients. In cases of primary sterility due to partial or complete tubal obstruction, the occurrence of genital tuberculosis has been established as 60% by Zondek[3].

Since the clinical and laboratory diagnosis of genital tuberculosis is usually very difficult and no other tests except the direct histological and bacteriological ones are yet available, the Middlebrook-Dubos reaction was tested as to its diagnostic value in those cases.

All patients with extragenital tuberculosis and those who were submitted to BCG or Mantoux previous to testing, are excluded from this study.

At first, cases were examined in which the diagnosis of genital tuberculosis was established by histological and/or bacteriological evidences. This group includes 13 patients all suffering from primary sterility. The following results were obtained:

4 cases 1:64 titre; 1 case 1:32; 1 case 1:16; 2 cases 1:8, and 5 cases were negative.

It has been observed that patients with high titres (1:64; 1:32) presented also clinical manifestations (menstrual irregularities, abdominal pains, adnexal palpatory findings, poor general conditions), while patients with lower titres or negative results were apparently healthy.

Taking into consideration the frequent occurrence of tuberculosis in cases of sterility due to partial or complete tubal occlusion, these patients formed the second group to be tested by haemagglutination reaction and compared with normal controls of the same age category. A total number of 145 patients were tested. The results are as follows:

	Number of examinations	*Titre higher than* 1:8	*Positive titres*				
			1:8	1:16	1:32	1:64	1:128
Sterility due to tubal occlusion	52	35(67.3%)	7	10	9	6	3
Normal controls	93	14(15.0%)	7	3	4	—	—

As may be seen from the table, 67.3% of the patients with chronic tubal inflammation have been found positive by the haemagglutination test. These results are quite consistent with the incidence of tuberculosis in women with tubal occlusion in this country[3]. On the other hand, 15% positive results were found in normal controls.

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REFERENCE

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2. Bamforth, J., *Modern Trends in Obstetrics and Gynecology*, Butterworth, London, 454.
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Summaries of Lectures Presented in the Section on Laboratory Methods and Procedures

A Microbiological Approach to the Nutritional Evaluation of Proteins

The methods presently available for the determination of the nutritional value of proteins in higher animals depend on a variety of biological responses. In the biological tests the rate of growth or gain of weight in young animals, or the maintenance of body weight in adults are measured as response to the different proteinaceous diets.

All these assays are laborious and time consuming.

A microbiological method for measuring the nutritional value of proteins is described. As a first step the different proteins are digested with *pancreatin*, an enzyme mixture performing proteolysis in the animal and human body. In the second stage we assay the growth promoting activity of the protein hydrolysates for *Streptococcus faecalis;* the test is carried out in a medium devoid of the 10 *essential* amino acids. Thus, the nutritive value of a protein is determined in a single assay by the particular amino acid liberated, by enzyme action, in limiting concentration.

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1. Bureau of Biological Research, Rutgers University, New Brunswick, N.J., 1950, Report on cooperative determination of the amino acid content, and of the nutrition value of six selected protein food sources.
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Storage of Bacterial Strains

Egg powder is mixed with pulverized glass and placed at 100°C in an open container until dry. While still warm, it is placed in a desiccator and kept over calcium chloride until cool. It is then distributed in about 1 ml portions in test tubes and kept at 120°C for one hour. For inoculation, the bacterial culture is washed off the slant with about 1 ml of a sterile solution consisting of equal parts of 2 per cent haemoglobin (Difco) in distilled water and 1.8 per cent sodium chloride solution. This is transferred by means of a pipette to the egg powder medium, which readily soaks up the bacterial suspension. The tubes are then overlayed with sterile paraffin oil and stored in an ice chest in household jars containing a small quantity of hydrated calcium chloride.

When a bacterial strain is needed, a few grains of the egg medium are taken out with a small sterile spoon and transferred to a fluid culture medium or spread over a solid agar plate with a small drop of sterile saline, using a platinum wire loop. There is no danger of contaminating the rest of the egg medium in the tube, and thus the tube may be used many times.

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The Turbidimetric Estimation of Bacterial Numbers[1]

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REFERENCE

1. KOCH, W. and KAPLAN, D., 1952, *Amer. J. Clin. Pathol.* **22**, 1181.

A Simple Method for Obtaining Highly Potent Tetanus Toxin[1]

W. KOCH
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REFERENCE

1. KOCH, W. and KAPLAN, D., 1953, *J. Immunol*, **10**, 1.

Antigenic Structure, Virulence and Taxonomy of Leptospira Grippotyphosa

Four strains of *L. grippothyphosa* were isolated from man, two from cattle and one from a goat, and their antigenic structure was compared with that of the classical grey strain moscou V and the bovine strain isolated by Bernkopf *et al.*[1] Rabbit immune sera prepared by immunization with strain *L. grippotyphosa* Moscou V agglutinated all other *grippotyphosa* strains up to the same titer. Immune sera with titers of 1:3,000 were diluted 1:10 and absorbed with great quantities of heterologous *Leptospirae* strains. The following results were obtained:

Strain Moscou V removed the agglutinins completely from its homologous antiserum and from all antisera prepared by immunization with local strains. while the majority of the local strains did not absorb all agglutinins from the anti-Moscou V immune serum.

Experiments with varying quantities of absorbing antigens showed that strain Moscou V and the bovine strain of Bernkopf removed from the anti-bovine strain serum exactly the same quantities of agglutinins, while excessive quantities of the bovine strain removed from the anti-Moscou V serum only its own agglutinins. It was, therefore, concluded that the bovine strain of Bernkopf contained only one antigen, while Moscou V contained two antigens, *g* and *b*. However, some strains isolated in Israel contained both antigens, *g* and *b*.

According to the rules of nomenclature, the name *L. bovis* given by Btesh[2] to the bovine strain of Bernkopf[1] cannot be maintained since this name was already given by Noguchi[3] to a strain observed in the gastric mucosa of an ox.

For the time being the antigenic analysis affords the best available method of differentiating *Leptospirae*, while differences in virulence, excretion in urine and persistance in organs of laboratory animals as proposed by Olejnik and Shneyerson[4] do not justify naming new species.

The goat strain was serologically identical with the bovine strain of Bernkopf[1]. Large quantities of the former appeared in the urine of white mice and hamsters, when the original infective material or subcultures were injected intraabdominally. It persisted in the kidneys of guinea pigs for three weeks. Another strain isolated from human blood was secreted in the urine of white mice for more than one year after intraabdominal injection.

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SUMMARIES of papers in Vol. II No. 4

NEUMANN, J. U.D.C. 551.573 (210.5+282.254.23)
Energy Balance of and Evaporation from Sweet Water Lakes of the Jordan Rift, Bull. Res. Counc. of Israel, 1953, 2, 337—357.

The paper presents the results of energy-balance calculations for determining the evaporation from the two sweet water lakes of the Jordan Rift. The results are as follows:

1) Annual amount of evaporation (± 15): Lake Tiberias: 162 cm: Lake Hula: 168 cm.

2) Annual variation of evaporation: Lake Tiberias: Double wave. Principal minimum in May, secondary minimum in January: principal maximum in October (month somewhat uncertain), secondary maximum in March. Lake Hula: Single wave. Minimum in December, maximum in July.

PICARD, L. U.D.C. 551.495 : 557.453
Outline on Groundwater Geology in Arid Regions, Bull. Res. Counc. of Israel, 1953, 2, 358—371.

Based on the experience gained in Petroleum Geology a classification of Groundwater Geology—with special emphasis of arid regions— is proposed. Sources, reservoirs, retainers and the various stratigraphic-, petrologic-, and structural-groundwater traps are discussed and illustrated.

FELDMAN-MUHSAM, B. U.D.C. 595.421
On the Identity of Haemaphysalis erinacei, and H. taurica, Bull. Res. Counc. of Israel, 1953, 2, 372—378.

H. erinacei Pavesi 1884 is re-established as a valid species and redescribed. *H. numidiana* Nn (1905) is sunk into synonymy with *H. erinacei* because of the priority of Pavesi's name. The description of the female of *H. erinacei* by Pavesi was based on nymphs of *H. excavatum* K. The type of the female of *H. erinacei* should therefore be that of *H. numidiana* Nn.

H. numidiana turanica Pos.-Str. is a synonym of *H. erinacei* Pav., while *H. numidiana taurica* Pos.-Str. is a synonym of *H. taurica* which is a valid species.

H. erinacei F.M. is sunk temporarily into synonymy with *H. taurica*. The female of *H. taurica* is described.

KOMAROVSKY, B. U.D.C. 581.526.325.2 : 639.311
A Comparative Study of the Phytoplankton of Several Fish Ponds in Relation to Some of the Essential Chemical Constituents of the Water, Bull. Res. Council of Israel, 1953, 2, 379—410.

A study of three types of fish-ponds in the Beisan Valley was carried out, and the relationship between some essential chemical constituents dissolved in the water (nitrogen, phosphorus and silicon compounds) and the development of phytoplankton was examined.

FURNESTIN, M. U.D.C. 595.135 (569.4)
Sur Quelques Chaetognathes d'Israel, Bull. Res. Counc. of Israel, 1953, 2, 411—414.

Un lot de 158 *Sagitta*, immatures pour la plupart, récoltées le long de la côte d'Israel, a fourni les cinq espèces suivantes: *S. friderici* R.-Z., *S. bipunctata* Q. et G., *S. enflata* Gr., *S. minima* Gr., *S. serrato-dentata* Krohn (= *S. serratodentata atlantica* T.).

Parmi ces espèces, il en est deux qui attirent des remarques particulières: *S. friderici* R.-Z. n'avait encore jamais été signalée en Méditerranée. *S. serrato-dentata* K. (= *S. s. atlantica* Tokioka), forme très halophile, se rencontre seule, aussi bien, dans le Bassin oriental que dans le Bassin occidental de la Méditerranée à l'exclusion de *S. serratodentata pacifica* Tokioka et *S. serratodentata tasmanica* Thompson, espèces à voisines crochets également serrulés.

MEYER, H. and BEN SHLOMO, E. U.D.C. 612.39 : 641.31 (569.4)
A Study of Nutrition Habits under Rationing Conditions in Israel, Bull. Res. Counc. of Israel, 1953, 2, 415—421.

1) All food consumed under rationing conditions by a family of four was weighed and analyzed for protein, fat and carbohydrate content during one month: 2) A pronounced appetite for eggs was shown by all family members and satisfied by the supplementation of the ration by eggs *ad libitum*: 3) Supplementing of eges was proved to be unnecessary, since the unsupplemented ration was complete with respect to protein and amino acids; 4) Caloric intake was low, owing to inadequate cooking and eating habits thus causing an abnormal high desire for proteins, which subsided when larger quantities of carbohydrates were eaten.

AVNIMELECH, M. U.D.C. 551.782.2 (569.4)
Studies of the Neogene of Israel, I. A New Pliocene Outcrop in the Central Coastal Plain of Israel, Bull. Res. Counc. of Israel, 1953, 2, 422—424.

A new Neogene outcrop, S of Ramle, confirms former observations. It is concluded that the marine regime of Helvetian-Tortonian ended with faulting and volcanism, which created external and inner fault-basins, Pliocene, in Asti- and Plaisancian facies, has transgressed upon the present Coastal Plain and the adjoining depressions.

ילקוט המועצה המדעית לישראל

כרך II   מרץ 1953 (הוצ״ל אוגוסט)   מס׳ 4

המחבר מהשב את מאזן החום של ים כנרת ושל ימת–החולה במטרה להגיע להערכה מדויקת ככל האפשר של כמות ההתאדות השנתית ומחזורה העונתי של ההתאדות בכל אחד מבין שני האגמים. תוצאות חשוביו הן כדלקמן: 1) הכמות השנתית של ההתאדות: מים כנרת —162 ס״מ; מימת־החולה — 168 ס״מ. 2) המהלך העונתי של ההתאדות: ים כנרת — גל כפול, המינימום העיקרי של ההתאדות חל בחדש מאי והמינימום המשני בחודש ינואר. המכסימום העיקרי חל בסתיו (בערך בחודש אוקטובר), המכסימום המשני בחדש מרץ; ימת־ההולה — גל כפול, המכסימום חל בחודש יולי, המינימום בחודש דצמבר.

הוצע למיין מחדש את הגיאולוגיה של מים תת־קרקעיים — במיוחד בשטחים צחיחיים — על יסוד הנסיון שנרכש בגיאולוגיה של נפט. הודגמו ונידונו מקורות, ברכות אגירה, מיכלי־מים, ומקוות מים כסטרטיגרפיות, פטרולוגיות וסטרוקטורליות שונות מתחת לאדמה.

לשם, 1884, Haemaphysalis erinacei Pavesi שנחשב תמיד לשם חסר תכן, ניתן תקף מחדש, מין זה מתואר כאן מחדש על יסוד קרצית הטיפוס המקורית של Pavesi. המין, H. numidiana, Neumann, 1905, אשר נחשב עד עתה למין טוב, צריך להחשב כסינונים ל־ H. erinacei, היות ולשם של Pavesi יש זכות קדימה. כנקיבה של H. erinacei מתאר Pavesi נימפות של Hyalomma cxcavatum K. הטיפוס של הנקיבה של המין H. erinacei צריך להיות אם כן טיפוס הנקיבה של H. numidiana. H. numidiana turanica Pospelova-Strom הוא סינונים ל־ H. erinacei Pavesi. H. numidiana turanica Pospelova-Strom הוא סינונים ל־ H. taurica, שהנו מין טוב, H. erinacei Feldman-Muhsam, 1952 נחשב באופן זמני כסינונים של H. taurica. ניתן תאור של הנקיבה של H. taurica.

נחקרו שלשה מיני ברכות־דגים בעמק הבשן, ונבדק היחס בין המרכיבים הכימיים העיקריים שבתמיסה במים (תרכובות חנקן, זרחן, וסיליקון) והתפתחות פיטופלנקטון.

בין 158 Sagitta שנאספו בחופי ישראל, רובם בלתי מבוגרים, נמצאו חמשת המינים הבאים: S. friderici R.-Z., S. serrato-dentata Krohn (=S. serratodentata atlantica T.), S. minima Gr., S. enflata Gr., S. bipunctata Q. et G.

על שני מינים מאלה יש להעיר: S. friderici R.-Z. טרם נמצאו בים התיכון. S. serrato-dentata K. (=S. s. atlantica Tokioka) צורה הלופילית ביותר, הנה הצורה היחידה הנמצאת בחלק המזרחי והמערבי של ים התכון. S. serratodentata pacifica Tokioka, S. serratodentata tasmanica Thomson מינים קרובים מאד לקודם, לא נמצאו.

כדי לבדוק אם המנה הקצובה מספקת את כל הצרכים, נבדק המזון של משפחה במשך 4 שבועות בדיוק האפשרי. המשפחה היתה מורכבת משני הורים, בני 41 ו־38 ומשני ילדים בני 6 ו־ 2. המזון הכיל את המנות הקצובות, פרט לביצים, שנוספו כאשר גילו חברי המשפחה את התאבון לביצים נוספות (מעל למנות הקצובות). נתגלו העובדות הבאות: 1) מנת המזון ספקה לכל חברי המשפחה את הכמויות הדרושות של הלבון, הויטמינים האמיניות ההכרחיות, ושומן. 2) תוספת הביצים לא סיפקה אלא כ־ 10% הלבון נוסף למנה; נמצא שתוספת כזו היא מיותרת. 3) מספר הקלוריות שקבלו כל חברי המשפחה היה קטן מדי. תופעה זו נגרמה לא ע״י מחסור, אלא ע״י הרגלי אוכל ובישול בלתי מתאימים, שגרמו גם לתאבון יתר על המידה לחלבונים. 4) נתינת כמויות גדולות יותר של פחמימיות ביטלה את התאבון הבלתי רגיל לחלבונים.

מחשוף חדש של ניאוגן שנתגלה דרומית מרמלה מאשר הסתכלויות קודמות. המסקנה היא כי גיאות הים של זמני הלוט־טורטון נסתיימה בשבירה ופעולות וולקניות, שיצרו אגנים פנימיים וחיצוניים. הים הפליאוקני, שהציף את מישור החוף הנוכחי ואת העמקים הסמוכים, השאיר בשטחים אלה סדימנטים בעלי אופי אסטי או פליונטי.

המועצה המדעית לישראל

BULLETIN
OF THE
RESEARCH COUNCIL OF ISRAEL

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THE ISRAEL MATHEMATICAL UNION

On Monday September 28, 1953 at 10 A.M., a meeting of the Israel Mathematical Union will take place at the Institute of Mathematics, The Hebrew University of Jerusalem in the northern annex of the King David Hotel building.

In the morning, short lectures on original mathematical research will be delivered. In the afternoon, pedagogical problems of the teaching of mathematics in secondary schools will be discussed by Prof. A.H. Frankel who will deal with several aspects of the problem — among them — the relationship between the teaching of mathematics and of physics. The same subject will be discussed also by Dr. Glickson. Mr. S. Marshak will speak on the degree of accuracy in the teaching of mathematics in secondary schools. The lectures will be followed by a general discussion.

A report on the Israel Mathematical Union and of its first meetings will be given in Volume III No. 2 of this journal.

THE ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE IN ISRAEL

The first meeting of the Association for the Advancement of Science in Israel will pe opened on Monday evening September 28 by Prof. B. Dinur, Minister of Education in Binyanei Haooma, Jerusalem in the framework of the Conquest of the Desert Exhibition.

The meeting will be devoted to the development of Israel's natural resources, and thereby her economy, through Science.

Among the lecturers on Tuesday, September 29 will be Prof. M. Evenari of the Hebrew University of Jerusalem, Prof. E.D. Bergmann of the Scientific Department, Ministry of Defence and Prof. A.H. Frankel of The Hebrew University of Jerusalem.

Participants in the meetings will tour the Conquest of the Desert Exhibition.

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